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SCIENTIFIC RESEARCH AND PUBLIC EXPENDITURE

THE statistical survey of scientific and technical research in British industry recently made by the Industrial Research Secretariat of the Federation of British Industries, while admittedly incomplete, is a valuable supplement to the survey of expenditure on research and development which formed the subject of the Third Report of the Select Committee on Estimates for the Session 1946–47 (132–1. London : H.M. Stationery Office, 1947. 6*s*. net). The Federation's report is based on the 471 replies received to about nine hundred copies of a questionnaire circulated to industrial firms known or thought likely to be carrying out research. It is estimated that the survey covers some seventy-five per cent of the industrial research effort of Great Britain, although probably not more than fifty per cent of the firms carrying out research. On this assumption the total annual expenditure by industry on research and development within its own establishments is of the order of thirty million pounds, which represents about two thirds of one per cent of the total annual value of British manufacture.

This figure may be compared with that of £5,442,000 obtained from an earlier survey by the Federation and based on returns from 566 firms in 1938 ; but it is more pertinent to set it against the national estimated expenditure of £69 millions analysed in the report of the Select Committee on Estimates. The estimate for the Department of Scientific and Industrial Research for 1947–48 amounts to £3,118,289, or about ten per cent of the expenditure by industry itself ; but in addition it is estimated that other Departments are expending £1,500,500 on industrial research. The vote for Post Office research amounts to £750,000, for agricultural and fisheries research to £2,150,925, for medical research to £710,850, for research in the Dominions and Colonies to £538,825. In addition to miscellaneous grants for scientific investigation amounting to £70,560, account should also be taken of the expenditure by the universities on scientific research. This is of fundamental importance to the State as well as to industry, but it is difficult to obtain even an approximate idea of its magnitude. Expenditure on teaching cannot, of course, easily be separated from that on research, and the Select Committee estimates that of the present vote of £11,875,000 in aid of the universities, something less than £3,500,000 is for science, technology and agriculture. Part of the expenditure of just over £2 millions on medical and dental education will be for research, and there are also capital grants of probably not less than £1,800,000 ; but it would be rash to put the nation's expenditure on fundamental research as reaching anywhere near £5 millions, at least on these figures.

What overshadows all these sums, however, is the expenditure of £60,351,000 on research and development for the Admiralty and the Ministry of Supply, which is more than double the total estimated research expenditure of the whole of British industry. The Select Committee refrains from detailed

comment as it proposes to deal with the problem of expenditure on defence research in a later report; but there is a *prima facie* reason for questioning whether the present distribution of expenditure on research and development is that most to be desired in the light of civil and military needs and national resources at the present time. The diversion of at least a third of this effort from defence purposes to civil research has been urged by the Association of Scientific Workers; but without the detailed returns supplied to the Select Committee, which it was considered undesirable to publish, it is not easy to judge whether a diversion of such magnitude would be desirable.

What is imperative is that the nation's expenditure on fundamental research, upon which defence no less than industrial development alike depend, should be used to the best advantage. There can be little doubt that our first concern should be, as Sir Henry Dale urged at Dundee, to promote the extension of fundamental knowledge, and build up again our scientific capital on which the needs of war have drawn so heavily. It is vital that our academic leaders of research, men with ideas and inspiration, should lack neither disciples, assistants, nor equipment. In urging this, Sir Henry Dale was thinking largely of the diversion of scientific minds from creative research to administrative work; and the present shortage of scientific man-power makes it important that due regard should be had to this danger, all the more because our war experience has demonstrated that the field in which the scientific worker can usefully operate extends far beyond that of the laboratory where he normally pursues his business.

That point was well made by Sir Edward Appleton in his A. D. Little Memorial Lecture* at the Massachusetts Institute of Technology in November 1946, when he indicated that, as emphasized in the Barlow Report, the Government order of priorities is now: universities and fundamental research; civil research (Government and industrial); and defence research. What needs to be remembered first, however, in this connexion, is that the limitations on expansion of fundamental research are not primarily financial but those of man-power. It was made clear in the evidence received by the Select Committee on Estimates that lack of money is not the difficulty holding up the pursuit of profitable new lines of research at the present time: the principal needs are for men and accommodation.

These two needs are closely linked, and both are bound to be affected by the Government's policy of priorities and of the restriction of capital expenditure due to the economic crisis. The Select Committee emphasizes that, while it may be open to question whether the allotment to pure research and to scientific teaching is adequate to secure the twin objects of gaining natural knowledge, which provides the foundation for the whole structure of applied science, and of providing the required output of trained research workers, the evidence suggests that the allocation for the current year is probably as much as can be usefully and economically absorbed. This problem is raised, and also the further question whether the expenditure on defence research represents an equitable distribution between civil and military needs; and on the adequacy of the rough estimate of 21 per cent of national expenditure on research for industrial research, no comment is made.

On that point an appended memorandum from the Department of Scientific and Industrial Research gives a little further information. Of the present vote, £942,000 represents grants to research associations, a figure which it is estimated will reach £1 million when the expenditure of the Department reaches its full post-war level of £4,035,000. Of the firms replying to the questionnaire from the Federation of British Industries and expending more than £1,000 per annum on research, ninety per cent possess their own separate research laboratory or department and thirty per cent carry out research in their own production department; while available estimates indicate that half the firms contemplate a twenty-five per cent increase of qualified research staff by the end of 1947 and a comparable further increase between 1948 and 1950.

These figures alone attest the importance of precise surveys of man-power requirements in relation to the expansion of the universities and colleges of technology, as was indicated recently in these columns (see *Nature*, November 29, p. 742). The memorandum from the Department of Scientific and Industrial Research, however, directs attention to the third factor in the situation, on which the Select Committee also comments. The Department of Scientific and Industrial Research, in addition to its primary responsibility for promoting and organising scientific work with a special view to its application to trade and industry, has also a duty to carry out scientific research within its scope required by other Departments of State. The memorandum indicates the provision being made for the discussion of common problems necessary for the most effective co-ordination; one responsibility of the new central intelligence group of the Department will be to make themselves generally familiar with what is going on in university and Government research organisations and, so far as possible, with the needs of industry, and then to effect such cross-fertilization as they can.

On the industrial side, the Federation of British Industries, through its Industrial Research Secretariat, is already doing much to promote the general exchange of scientific and technical information, and the inquiry indicated that most firms are satisfied with present arrangements. The Select Committee on Estimates, commenting on the dangers of overlapping and waste of effort in the present administrative organisation, emphasizes the value and need of a first-class system of liaison at all levels and the greatest possible interchange of information not only on results, but also on projects. It was satisfied that, in general, improvements in the existing organisation are being made as weak spots are revealed, and since

* Science, Government and Industry. By Sir Edward V. Appleton. (Inaugural of the Arthur Dehon Little Memorial Lectures at the Massachusetts Institute of Technology, at Cambridge, Massachusetts, November 19, 1946.) Pp. 38. (Cambridge, Mass.: Massachusetts Institute of Technology, 1946.)

these matters are under consideration by the Defence Research Policy Committee and the Advisory Council on Scientific Policy, it makes no further comment.

The Select Committee agrees with the opinion, which Sir Edward Appleton expressed at the British Commonwealth Scientific Conference last year, that it is far too early to decide what the ideal Government organisation for research should be, and the machinery for fostering scientific effort must remain for many years in a state of active development. That, however, does not exclude the need for closer study of the whole question of the organisation of scientific and industrial research in Great Britain, and indeed is a reason for further trial and experiment with the forms of institution best likely to achieve our purposes. There is general agreement, both in Great Britain and in the United States, that fundamental research is seldom a proper field for Government expenditure and that Government assistance is best given indirectly, through block grants to universities, research institutes and even individuals; but even here there may be room for inquiry as to whether there is in Britain a sufficiency of research institutions of the range and type to ensure that all branches of science are adequately covered. While the urgency of the present need for more and more production makes it essential to drive existing institutions to the utmost, the general unrest following a great war nevertheless provides both the right atmosphere for experiment with new ways of approach and the incentive to extract from each everything that can be of value for the future.

SYNTHETIC RUBBER

Butalastic Polymers

Their Preparation and Applications; a Treatise on Synthetic Rubbers. By Frederick Marchionna. Pp. vii+642. (New York: Reinhold Publishing Corporation, 1946.) 8.50 dollars.

THE development of synthetic rubber is one of the outstanding achievements of chemical industry in recent years. The chronicler of the story of this achievement is, however, faced with a multiplicity of difficulties. A comprehensive account must include, first the manufacture of the monomer, second the polymerization of the monomer, and third the fabrication and properties of a wide variety of articles made from rubber. The first part is a matter of large-scale industrial catalytic chemistry where the essential techniques are already well established in other fields of chemical engineering. The second is based on scientific principles, but is also compounded of much empiricism because there has not been time to go into these principles in an adequate manner so that the mechanism of polymerization is fully understood. The third is rubber technology applied to materials which have usually turned out to be rather more difficult to work with than natural rubber. Further, developments have mainly occurred in the United States, Germany and the U.S.S.R., and there has naturally been no interchange of information between these countries. Even if there had not been a world war, it is extremely doubtful whether the operators in these respective countries would have divulged the 'know how' regarding these processes so that an author could write a critical summary of the present-day position.

Dr. Marchionna has therefore had to face very considerable difficulties in writing an up-to-date account of the subject. The book was written before much information became available through the Allied teams of investigators sent to Germany and before the vast amount of work done for the rubber research programme in the United States began to appear in the scientific literature. There was thus only available to the author a considerable volume of earlier published work on the attempts made to synthesize rubber-like materials and a host of patents relating to the possible processes for the manufacture of monomer, for the polymerization of monomers and for the working up of the rubbers so produced; but of course with little guidance as to their real worth or economic practicability. In view of this awkward state of affairs, it is impossible to prepare a critical account of the various phases of the subject or even to give a personal opinion of the relative merits of competing processes or the various types of rubber now commercially available.

The contents of the book are restricted to what the author conveniently terms butalastic polymers, that is to say, synthetic elastomers in which the repeating unit was originally a diene. The volume is divided into three parts. The first deals with laboratory and technical methods of making isoprene, dimethyl butadiene, butadiene and halogen derivatives of dienes. Although butadiene is now regarded as the most important diene, the space devoted to it is perhaps a little disproportionately small. Part 2 is devoted to the problems involved in polymerization. Here the emphasis is mainly on the methods found empirically for diene polymerization, and there is no general account of polymerization from the kinetic point of view. Again this is reasonable, because diene polymerization has not yet yielded to accurate kinetic methods in view of the many complications that arise, especially in emulsion or sodium polymerization. Unfortunately, the lack of published information has precluded a detailed description of the processes currently used in the United States. Part 3 describes the technology of synthetic rubber, dealing with the coagulation of the emulsion and the incorporation of the usual rubber-compounding agents. Then there are sections dealing with all the usual applications of rubber in industry, special note being paid to the properties of synthetic as contrasted with natural rubber. There are comprehensive indexes to the book, which is well produced and excellently printed.

This, then, is the first comprehensive attempt to give a balanced and connected account of an industry which started many years ago, developed very slowly indeed and did not really come into its own until war compelled a tremendous amount of scientific and technological effort to be brought to bear in order to make certain that synthetic rubber would, in fact, be a practical proposition. Dr. Marchionna has attained success in a very difficult task. Any shortcomings which the book possesses are in the main due to the information not being available. It is to be hoped that when a second edition is required the war-time experiences will be incorporated, so that the reader can then discover what indeed are the scientifically and economically satisfactory ways of making and manipulating synthetic rubber.

H. W. MELVILLE

BIOLOGICAL SIGNIFICANCE OF NUCLEIC ACID

Nucleic Acid

(Society for Experimental Biology Symposia No. 1: Published for the Company of Biologists on behalf of the Society for Experimental Biology.) Pp. vii+290+18 plates. (Cambridge: At the University Press, 1947.) 35*s*. net.

IN 1914 Walter Jones began the preface to his monograph on nucleic acids with the words, "The nucleic acids constitute what is possibly the best understood field of Physiological Chemistry . . ." That was then a tenable point of view; but twenty years later it would have been absurd. There are fashions in everything, including biochemistry, and nucleic acids went largely out of fashion or were swamped by the growth of our knowledge of proteins, oxidation mechanisms and the other processes that characterized the development of biochemistry in the 1930's. The boom–slump–boom cycle is, however, not confined to economics, and a nucleic acid boom is now upon us. Much new knowledge of the intrinsic properties and biological behaviour of the nucleic acids has been gained during the past few years; but there seems to have been a disproportionate flood of review articles, conferences and symposia. Stocktaking is valuable, but what is now needed in cytochemistry is more stock rather than more surveying.

The present volume gives the text of nineteen papers delivered at a symposium in Cambridge in 1946. The first articles deal with the chemical and physico-chemical properties of nucleic acids and nucleotides, and in them emphasis is placed on the large body of pure assumption that has in the past done duty for knowledge in the field. The late Prof. J. Masson Gulland and his colleagues survey the structural evidence that can be derived from degradation experiments, and point out that the abandonment of the tetranucleotide structure greatly increases the theoretical possibilities of isomerism among the nucleic acids. Evidence on structure is also given in Lythgoe and Todd's brief but lucid description of their extensive series of nucleotide syntheses. Kalckar describes new techniques for the microanalysis of purines by ultra-violet absorption, and gives some of the metabolic conclusions gained with them.

A thoughtful critique of the validity of many cytochemical methods, by Danielli, makes a good introduction to the more biological part of the symposium. Brachet and Caspersson present much evidence that regions or times of intense protein synthesis are correlated with a high nucleic acid content. Although each individual piece of evidence is not by itself wholly convincing, the accumulated mass is most impressive. Two other articles stand in interesting contrast. With pleasing exuberance, Darlington speaks of "nucleic acid as the molecular midwife of all reproductive particles" but, while re-writing cytology, gives no hint, in this article, of the technique and observations on which his conclusions are based. Stedman proceeds more cautiously and continues his valuable attempt to convince cytologists and geneticists that there is more in the nucleus than protamine or histone and nucleic acid. There is perhaps a danger that a new dogma may be built up if the unfractionated protein that can be extracted from all the nuclei that have been studied is called 'chromosomin'. That other proteins are present is obvious; that these proteins are sufficiently uniform in chemical type to deserve a name is arguable.

The printing and format of the book, which appears to be the first of a new series, are good; but it is a pity that the titles of papers have been put at the head of both left- and right-hand pages. It would have been helpful to have the author's name on one side. It is also a pity that such a high price had to be charged for a work which, although useful, is essentially ephemeral.

N. W. PIRIE

NOAH'S NIGHTMARE

Built Before the Flood

The Problem of the Tiahuanaco Ruins. By H. S. Bellamy. Revised and enlarged edition. Pp. 192. (London: Faber and Faber, Ltd., 1947.) 21*s*. net.

TIAHUANACO is an important site in South American archæology, and although it is not the only one, it has something about it which, like Glastonbury, stimulates the imagination of the uncritical, who tend to exalt it above all others. Here are some facts which must be borne in mind in considering it in relation to the subject as a whole. Not only its famous stone ruins but also its pottery belong to a very characteristic and easily recognized style. Their distribution in the Andes is restricted to the neighbourhood of Tiahuanaco itself, but on the coast a closely related style in pottery and textiles, little later than the culmination of the style in the Andes, is widespread. This is later than the well-known Mochica culture of the north coast, now dated with some certainty at *c*. A.D. 1000. When due allowance has been made for the time taken for Tiahuanaco influence to spread from the Andes to the coast, this shows that some time late in the first millennium is a reasonable estimate for its date. In the central and south parts of the coast, pre-Tiahuanaco cultures, earlier than the Mochica but still datable within the first millennium A.D., have yielded abundance of perfectly preserved textiles and other fragile and perishable materials in shallow graves, owing their very existence to continuous drought since they were buried. In the extreme north of Chile, it has been proved that the relation between land and sea cannot have altered more than about 15 metres at the outside (in the sense of a rise of land) since the arrival of pre-pottery man, long before any sign of Tiahuanaco influence.

The contention of this book is, briefly, that Tiahuanaco was built "certainly not less than a quarter of a million years ago", when a satellite preceding the moon dominated the heavens, and that it was overwhelmed by a great "girdle tide" which this satellite raised in the equatorial regions shortly before its disintegration. These ideas are based on the speculations of an Austrian named Hoerbiger, and it is claimed that the carvings on the monolithic gateway at Tiahuanaco constitute a calendar which fits in with his scheme. That we are not told how the older fragile remains on the coast survived an inundation of some 14,000 ft. of water and other catastrophic happenings is a consequence of the failure to consider a site in its context, which is frequent in this sort of writing.

The age ascribed to the ruins makes them contemporary with part of the European palæolithic period, when it is most unlikely that man, even at

that lowly stage of development, had reached any part of the American Continent. On the other hand, the idea that a satellite approached the earth and disintegrated, and that the moon was 'captured', all in Pleistocene times, is unlikely to commend itself to men of science. In view of the startling contradiction between Mr. Bellamy's conjectures and the geological time-scale, it is lost labour to follow him through the tortuous paths of his interpretation of the carvings on the Tiahuanaco gateway. This has given rise to divers interpretations—it has even been claimed that it has something to do with the Old Testament—but there is no reason whatever why it should have been a calendar.

This book first appeared in 1943, and it was reprinted in 1944. That there should now be a "new revised and augmented edition", little altered except for a six-month shift in certain signs and the addition of twenty-seven pages of astronomical explanation by another author, provokes the suggestion that its vogue may be due to the hardness of the times which drives men to seek escape in fantasy.

G. H. S. BUSHNELL

EVOLUTION ON GALAPAGOS

Darwin's Finches

By David Lack. Pp. x + 208 + 9 plates. (Cambridge: At the University Press, 1947.) 21*s*. net.

THE theories of Darwin, and particularly those propounded in the "Origin of Species", are subjects of evergreen interest both to laymen and to biologists, and it is constantly worth while to examine and re-examine them in the light of the newest knowledge. To-day it can be said that they have stood the test of years of antagonistic criticism and of more than a generation of precise biological research, and have re-emerged so triumphantly that Prof. R. A. Fisher has recently spoken of a renaissance of Darwinism. It is therefore of special interest to read Mr. Lack's account of the latest expedition to what is perhaps the most important region visited by Darwin, the Galapagos Islands, and to learn more of the peculiar fauna of that place. What Darwin himself once said is still true: "The natural history of these islands is eminently curious, and well deserves attention".

The Islands are oceanic, and their colonization by land animals appears to have been haphazard and of rare occurrence. To-day the main ecological niches are fully occupied, but by most unusual species. The present account concerns in particular the four genera and fourteen species of birds which have become known as Darwin's finches. It is presumed that they have all evolved from a common stock, a small group of immigrants from the American mainland, and that some of them, experiencing no competition but their own from that time onwards, have undergone unique modifications of structure and habit. Some of them, the ground finches, retained the seed-eating habit, but others, the tree finches, became insectivorous. Of the whole series, the most extraordinary are the woodpecker finch and the warbler finch. Had the niches now occupied by these two birds been already filled by a true woodpecker and a true warbler, it is suggested that such development could never have taken place.

The first lesson which the Islands teach is the great variety which can develop in a small virgin country from a severely restricted beginning, a lesson which is repeated there by many other animals and by the plants. A second is the paramount importance of geographical isolation for species formation. Not only has it been necessary that the colonists should be cut off from their parent stock, but the theory is also advanced that each of the various finch species must have arisen in the isolation of one or other of the Islands and later extended its range. To-day, where they meet, the species persist only because they have come to occupy different ecological niches, and this in turn must have tended to increase their specialization. In contrast, the only one of Darwin's finches which is present on Cocos Island has remained a single species. The situation of Cocos ensures almost complete isolation from the mainland, but being a single small island it offers no chances of isolation within its borders.

Mr. Lack's restatement and development of the problem of Darwin's finches is admirably done. The material summarized, the reviews which are given of past and present theories, as well as the individual views expressed by the author, are all highly stimulating and valuable, and there is an extensive bibliography. The style is pleasant, the printing is excellent, and although the photographs are not up to present-day standards, the illustrations are adequate. It is a book which will be of great interest to all those, amateur and professional, who are intrigued by the problems of the origin of species.

W. S. BULLOUGH

INTRODUCTORY BIOLOGY

Biology for Medical Students

By C. C. Hentschel and Dr. W. R. Ivimey Cook. Pp. xii+752. (London, New York and Toronto: Longmans, Green and Co., Ltd., 1947.) 25*s*. net.

IN the fourth edition of this widely used text-book the authors have taken the opportunity of considerable revisions of both the text and the illustrations. This applies particularly, so far as the text is concerned, to the botanical part; fewer changes and additions have been made in the zoological section, though there, too, the alterations are extensive.

The botanical part of this text-book has now grown to a well-rounded introduction to botany, which in scope might indeed be of use to a first-year science student; plant physiology has been extensively treated, and it was the aim of the authors to lay in this way the foundations for a later study of human physiology. The zoological part covers fully the requirements of the first-year medical student.

Criticism concerns chiefly the illustrations. Though a great number of the photographs are excellent, the quality of the diagrams varies considerably. Illustrations of the same organ in the three vertebrate types under discussion (for example, the inner ear, Figs. 255, 277 and 305, or the heart, Figs. 240, 267, 293 and 294) are not comparable and make a comparative appreciation by the student very difficult. Some of the drawings (for example, Fig. 268 or Fig. 300) are reduced too much and the many labelled details can only cause confusion; and the student will find some drawings of the chick's embryology very difficult to understand.

But in spite of these blemishes the new edition will continue to be a useful guide to the medical student in his first-year work.

A. S.

Theory of Lie Groups, I

By Claude Chevalley. (Princeton Mathematical Series.) Pp. xii + 217. (Princeton, N.J.: Princeton University Press; London: Oxford University Press, 1946.) 20*s*. net.

IN recent years great advances have been made in our knowledge of the fundamental structures of analysis, particularly of algebra and topology, and an exposition of Lie groups from the modern point of view is timely. This is given admirably in the book under review, which could well have been called "Lie Groups in the Large". To make such a treatment intelligible it is necessary to re-examine from the new point of view such subjects as the classical linear groups, topological groups and their underlying topological spaces, and analytic manifolds. Excellent accounts of these, with the study of integral manifolds and their constructions in the large, are given in the earlier chapters. In Chapter 4 we come to the definition of an analytic group and its underlying manifold, and to the introduction of the important concept of a Lie algebra associated with an analytic group. A Lie group is then defined as a locally connected topological group related in a certain way to some analytic group; from this it follows that the concept of Lie algebra can be used freely when dealing with Lie groups. Chapter 5 contains an account of Cartan's calculus of exterior differential forms and its application to the theory of Lie groups. The final chapter is concerned with compact Lie groups, and after a brief consideration of the general theory of representations it is proved, among other things, that every representation of a compact Lie group is semi-simple.

The style of writing, though very condensed, is clear, and the printing is excellent. The notation is that of the modern school, with 'union' (∪) and 'intersection' (∩) in place of the older 'sum' and 'product' of sets. (A misprint has unfortunately interchanged the symbols ∪ and ∩ in their definition on p. xii.) The author promises a second volume, to be mainly concerned with semi-simple Lie groups.

A. G. WALKER

Animal Nutrition

By Prof. Leonard A. Maynard. (McGraw-Hill Publications in the Agricultural Sciences.) Second edition. Pp. xviii+494. (New York and London: McGraw-Hill Book Co., Inc., 1947.) 25*s*.

THIS is one of the very few books which deal adequately with the fundamentals of the biochemistry and physiology of nutrition and with the applications of this knowledge to the feeding of farm animals. Since the first edition was published some nine years ago, much of the newer knowledge of nutrition has emerged, and this has meant extensive alterations in the sections on amino-acid, vitamin and mineral nutrition. In his preface, the author points out that owing to the limited opportunity which was enforced by war and its aftermath, it has been impossible to take account of the results of recent research in foreign countries, because the data have either remained unpublished or the journals containing them have not reached his desk. The student is warned by the author that he should not thereby gain a distorted picture of the progress of our knowledge of this very important field of physiology and chemistry. The present volume takes us up to the end of March 1946.

It is difficult to single out any particular parts for special comment, but the chapter on mineral deficiency is especially well treated, and the chapters on feeding experiments contain one of the best reasoned discussions on the pros and cons of the paired-feeding technique. In the author's view this method would appear to find its largest usefulness in comparisons in which food consumption is not markedly restricted by the conditions imposed, and in which the measure is in terms of the specific effect of the nutrient under study, instead of the more general measure of increase in weight. It is considered that there are many problems concerning which the use of separate experiments of both *ad libitum* and controlled feeding will give much more information than either procedure alone.

The chapters on growth, reproduction, lactation and work production are likewise excellent. In its clarity and brevity this work has few equals.

D. P. CUTHBERTSON

Photoelectric Cells

By Dr. A. Sommer. (Methuen's Monographs on Physical Subjects.) Pp. viii+104. (London: Methuen and Co., Ltd., 1946.) 5*s*. net.

DR. SOMMER is well known for his work on photo-electric cells, and in this monograph he collects the basic work done by himself and others between 1931 and 1945. While there have been excellent texts on the industrial applications of photo-electric devices, there appears to be no review of the theoretical and research work since about 1934, so we are grateful to Dr. Sommer for his work and his bibliography. He is here concerned solely with photo-emissive cells. Commencing with Hertz, Planck and Einstein, he outlines the theory of emission, and shows how the number of materials useful as photo-emitters is strictly limited by ionization energy and work function, as well as physical properties. He then deals with the relationship of the wave-length of the incident light, the resulting emission, and the effect of gas in the enclosure. The manufacture of photo-cathodes is then outlined, and also the way in which they can be used for practical applications. Of great value is his critical table outlining the suitable types of cells for established technology, such as photometry, sound-film reproduction, picture-telegraphy, and television.

L. E. C. HUGHES

City Region and Regionalism

A Geographical Contribution to Human Ecology. By Robert E. Dickinson. (International Library of Sociology and Social Reconstruction.) Pp. xv+327. (London: Kegan Paul and Co., Ltd., 1947.) 21*s*. net.

WHILE this book is not directly about planning, it deals with matters and conceptions that are essential to any far-sighted planning schemes. Human ecology, as the relation of society to the area in which it lives, is a difficult but most important study and one that is too often overlooked in schemes of administration. The spatial relations of human society is a study that has received too little attention in Great Britain. The city is a regional centre of a larger or smaller area, and its function as such is an important condition in delimiting regions within any country. Some cities weld together larger areas than others and size is not a necessary criterion of this function. Mr. Dickinson deals mainly with the town or city as a regional capital, but has also a good deal to say on the possible delimitation of regions in the United States, France and England and Wales. The book merits close attention.

EVIDENCE FOR THE EXISTENCE OF NEW UNSTABLE ELEMENTARY PARTICLES

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AMONG some fifty counter-controlled cloud-chamber photographs of penetrating showers which we have obtained during the past year as part of an investigation of the nature of penetrating particles occurring in cosmic ray showers under lead, there are two photographs containing forked tracks of a very striking character. These photographs have been selected from five thousand photographs taken in an effective time of operation of 1,500 hours. On the basis of the analysis given below we believe that one of the forked tracks, shown in Fig. 1 (tracks *a* and *b*), represents the spontaneous transformation in the gas of the chamber of a new type of uncharged elementary particle into lighter charged particles, and that the other, shown in Fig. 2 (tracks *a* and *b*), represents similarly the transformation of a new type of charged particle into two light particles, one of which is charged and the other uncharged.

The experimental data for the two forks are given in Table 1; H is the value of the magnetic field, α the angle between the tracks, p and Δp the measured momentum and the estimated error. The signs of the particles are given in the last column of the table, a plus sign indicating that the particle is positive if moving down in the chamber. Careful re-projection of the stereoscopic photographs has shown that each pair of tracks is copunctal. Moreover, both tracks occur in the middle of the chamber in a region of uniform illumination, the presence of background fog surrounding the tracks indicating good condensation conditions.

Though the two forks differ in many important respects, they have at least two essential features in common: first, each consists of a two-pronged fork with the apex in the gas; and secondly, in neither case is there any sign of a track due to a third ionizing particle. Further, very few events at all similar to these forks have been observed in the 3-cm. lead plate, whereas if the forks were due to any type of collision process one would have expected several hundred times as many as in the gas. This argument indicates, therefore, that the tracks cannot be due to a collision process but must be due to some type of spontaneous process for which the probability depends on the distance travelled and not on the amount of matter traversed.

TABLE 1. EXPERIMENTAL DATA

Photo-graph	H (gauss)	α (deg.)	Track	p (eV./c.)	Δp (eV./c.)	Sign
1	3500	66·6	*a*	$3{\cdot}4 \times 10^8$	$1{\cdot}0 \times 10^8$	+
			b	$3{\cdot}5 \times 10^8$	$1{\cdot}5 \times 10^8$	−
2	7200	161·1	*a*	$6{\cdot}0 \times 10^8$	$3{\cdot}0 \times 10^8$	+
			b	$7{\cdot}7 \times 10^8$	$1{\cdot}0 \times 10^8$	+

This conclusion can be supported by detailed arguments. For example, if either forked track were due to the deflexion of a charged particle by collision with a nucleus, the transfer of momentum would be so large as to produce an easily visible recoil track. Then, again, the attempt to account for Fig. 2 by a collision process meets with the difficulty that the incident particle is deflected through 19° in a single collision in the gas and only 2·4° in traversing 3 cm. of lead—a most unlikely event. One specific collision process, that of electron pair production by a high-energy photon in the field of the nucleus, can be excluded on two grounds: the observed angle between the tracks would only be a fraction of a degree, for example, 0·1° for Fig. 1, and a large amount of electronic component should have accompanied the photon, as in each case a lead plate is close above the fork.

We conclude, therefore, that the two forked tracks do not represent collision processes, but do represent spontaneous transformations. They represent a type of process with which we are already familiar in the decay of the meson into an electron and an assumed neutrino, and the presumed decay of the heavy meson recently discovered by Lattes, Occhialini and Powell[1].

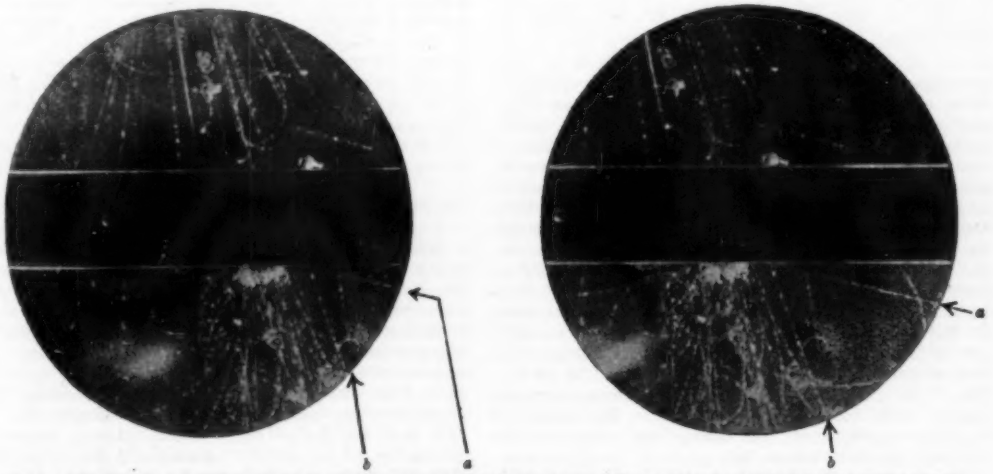

Fig. 1. STEREOSCOPIC PHOTOGRAPHS SHOWING AN UNUSUAL FORK (*a b*) IN THE GAS. THE DIRECTION OF THE MAGNETIC FIELD IS SUCH THAT A POSITIVE PARTICLE COMING DOWNWARDS IS DEVIATED IN AN ANTICLOCKWISE DIRECTION

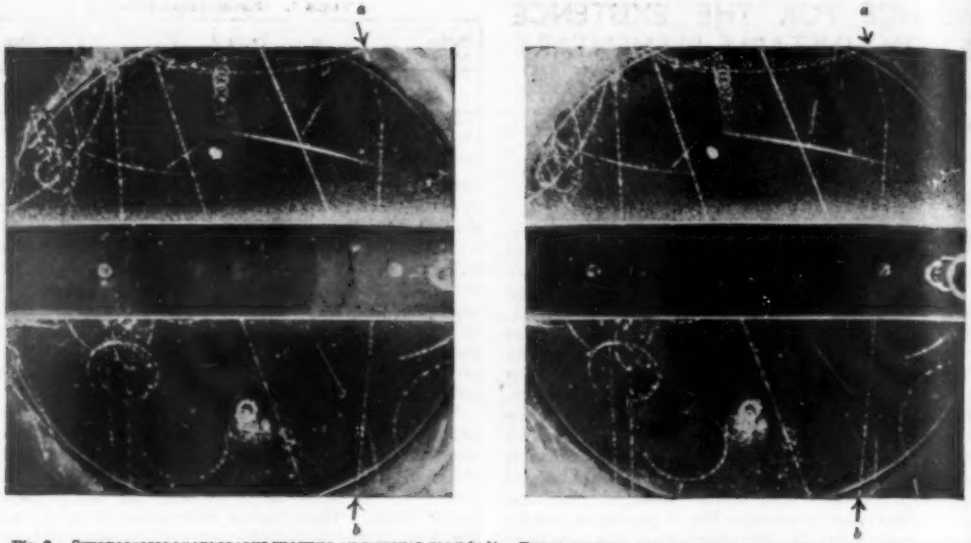

Fig. 2. STEREOSCOPIC PHOTOGRAPHS SHOWING AN UNUSUAL FORK (*a b*). THE DIRECTION OF THE MAGNETIC FIELD IS SUCH THAT A POSITIVE PARTICLE COMING DOWNWARDS IS DEVIATED IN A CLOCKWISE DIRECTION

The Masses of the Incident Particles

Let us assume that a particle of mass M and initial momentum P is transformed spontaneously into two particles of masses m_1 and m_2, momenta p_1 and p_2 at angles of θ and φ with the direction of the incident particle. Then the following relations must hold:

$$\sqrt{M^2c^4+P^2c^2} = \sqrt{m_1^2c^4+p_1^2c^2} + \sqrt{m_2^2c^4+p_2^2c^2} \quad (1)$$

$$P = p_1 \cos\theta + p_2 \cos\varphi \quad (2)$$

$$p_1 \sin\theta = p_2 \sin\varphi. \quad (3)$$

These general relations may be used to obtain the mass of the incident particle as a function of the assumed masses of the secondary particles.

The value of M must be greater than that obtained by taking the rest masses of the secondary particles as small compared with their momenta; thus the minimum value $M_{\min}$ is given by the following equation:

$$M_{\min}c^2 = c\sqrt{(p_1+p_2)^2} - P^2. \quad (4)$$

Applying this equation to the forked track of Fig. 1, after calculating P from the observed values of p_1 and p_2, it is found that $M_{\min}$ is $(770 \pm 200)m$, where m is the mass of the electron. The application of equation (4) to the forked track of Fig. 2, however, after calculating p_2 from the observed values of P and p_1, shows that $M_{\min} = (1{,}700 \pm 150)m$. This value of the mass would require an ionization for the incident particle of twice minimum, which is inconsistent with the observed ionization. We are therefore justified in assuming that the real value of P is greater than the observed value which, as indicated in Table 1, has a large error. If larger values of P are assumed, then $M_{\min}$ is reduced in value. The lowest value of $M_{\min}$ is $(980 \pm 150)m$ if P is $14{\cdot}5 \times 10^8$ eV./c. Beyond this value of P the mass increases slowly with increasing momentum. No choice of incident momentum will bring the mass of the incident particle below 980 m.

In the special case where the incident particle disintegrates transversely into two particles of equal mass m_0, giving a symmetrical fork, equation (1) reduces to the following expression,

$$\frac{M}{m} = \frac{2m_0}{m}\left(1 + \frac{p^2c^2}{m_0^2c^4} \cdot \sin^2\theta\right)^{1/2}, \quad (5)$$

where p is the momentum of each of the secondary particles. Some typical results for different assumed secondary particles, calculated from equation (5), are given in Table 2. On the reasonable assumption that the secondary particles are light or heavy mesons, that is, with masses of $200m$ or $400m$, we find that the incident particle in each photograph has a mass of the order of $1{,}000m$.

TABLE 2. MASS OF INCIDENT PARTICLE AS A FUNCTION OF MASS OF SECONDARY PARTICLE

Photograph	Assumed secondary particle m_0/m	Momentum of observed secondary particle (eV./c.)	Incident particle M/m
1	0	$3{\cdot}5 \times 10^8 \pm 1{\cdot}0 \times 10^8$	770 ± 200
	200	"	870 ± 200
	400	"	1110 ± 150
	1837	"	3750 ± 50
2	0	$7{\cdot}7 \times 10^8 \pm 1{\cdot}0 \times 10^8$	980 ± 150
	200	"	1080 ± 100
	400	"	1230 ± 100
	1837	"	3820 ± 50

Upper values of the masses of the incident particles may also be obtained from the values of the ionization and the momenta. Thus for each of the observed particles in Fig. 1, the ionization is indistinguishable from that of a very fast particle. We conclude, therefore, that $\beta = v/c > 0{\cdot}7$. Since the momentum of the incident particle may be found from the observed momenta of the secondary particles, we can apply equation (1) to calculate M. In this way we find $M/m < 1{,}600$. Again, since the ionization of the incident particle in Fig. 2 is light, $\beta > 0{\cdot}7$, from which it can be shown that $M/m < 1200$. This last result, however, must be taken with

caution because of the uncertainty in the measured value of the momentum of the incident particle.

One further general comment may be made. This is that the observation of two spontaneous disintegrations in such a small number of penetrating showers suggests that the life-time of the unstable particles is much less than the life-time of the ordinary meson. An approximate value of this life-time may be derived as follows. The probability of an unstable particle of life-time τ_0 decaying in a short distance D is given by

$$p = \frac{D(1-\beta^2)^{1/2}}{\tau_0 c \beta}. \qquad (6)$$

Since the total number of penetrating particles in the penetrating showers so far observed is certainly less than 50, we must assume that the number of our new unstable particles is unlikely to have been greater than 50. Since one particle of each type has been observed to decay, we can therefore put $p \approx 0{\cdot}02$. Setting $D \approx 30$ cm., and $\beta = 0{\cdot}7$, we find from equation (6) that $\tau_0 = 5{\cdot}0 \times 10^{-8}$ sec.

We shall now discuss possible alternative explanations of the two forks.

Photograph 1. We must examine the alternative possibility of Photograph 1 representing the spontaneous disintegration of a charged particle, coming up from below the chamber, into a charged and an uncharged particle. If we apply the argument which led to equation (4) to this process, it is readily seen that the incident particle would have a minimum mass of $1{,}280m$. Thus the photograph cannot be explained by the decay of a back-scattered ordinary meson. Bearing in mind the general direction of the other particles in the shower, it is thought that assumption of the disintegration of a neutral particle moving downwards into a pair of particles of about equal mass is more probable. Further, it can be stated with some confidence that the observed ionizing particles are unlikely to be protons because the ionization of a proton of momentum $3{\cdot}5 \times 10^8$ eV./c. would be more than four times the observed ionization.

Photograph 2. In this case we must examine the possibility of the photograph representing the spontaneous decay of a neutral particle coming from the right-hand side of the chamber into two charged particles. The result of applying equation (4) to this process is to show that the minimum mass of the neutral particle would be about $3{,}000m$. In view of the fact that the direction of the neutral particle would have to be very different from the direction of the main part of the shower, it is thought that the original assumption of the decay of a charged particle into a charged penetrating particle and an assumed neutral particle is the more probable.

We conclude from all the evidence that Photograph 1 represents the decay of a neutral particle, the mass of which is unlikely to be less than $770m$ or greater than $1{,}600m$, into the two observed charged particles. Similarly, Photograph 2 represents the disintegration of a charged particle of mass greater than $980m$ and less than that of a proton into an observed penetrating particle and a neutral particle. It may be noted that no neutral particle of mass $1{,}000m$ has yet been observed; a charged particle of mass $990m \pm 12$ per cent has, however, been observed by Leprince-Ringuet and L'héritier[3].

Peculiar cloud-chamber photographs taken by Jánossy, Rochester and Broadbent[3] and by Daudin[4] may be other examples of Photograph 2.

It is a pleasure to record our thanks to Prof. P. M. S. Blackett for the keen interest he has taken in this investigation and for the benefit of numerous stimulating discussions. We also wish to acknowledge the help given us by Prof. L. Rosenfeld, Mr. J. Hamilton and Mr. H. Y. Tzu of the Department of Theoretical Physics, University of Manchester. We are indebted to Mr. S. K. Runcorn for his assistance in running the cloud chamber in the early stages of the work.

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[2] Leprince-Ringuet, L., and L'héritier, M., *J. Phys. Radium*, (Sér. 8), **7**, 66, 69 (1946). Bethe, H. A., *Phys. Rev.*, **70**, 821 (1946).
[3] Jánossy, L., Rochester, G. D., and Broadbent, D., *Nature*, **155**,1 42 (1945). (Fig. 2. Track at lower left-hand side of the photograph.)
[4] Daudin, J., *Annales de Physique*, 11e Série, **19** (Avril–Juin), 1944 (Planche IV, Cliché 16).

THE GRASSHOPPER PROBLEM IN NORTH AMERICA

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OFFICIAL figures compiled by the Division of Grasshopper Control of the United States Bureau of Entomology show that in the ten-year period 1936–46, crops to the value of 424,563,614 dollars were destroyed by grasshoppers, and 26,088,211 dollars was spent on control measures. No similar statistics are available for Canada, where the general situation with regard to grasshoppers is similar. The annual figures for the same period show considerable fluctuation, apparently dependent on natural variations in grasshopper populations; but they do not suggest any general downward trend which might be interpreted as a cumulative result of persistent artificial control measures. It must be stressed that these measures are unquestionably very successful so far as the protection of standing crops of the year is concerned, and the organisation of control, based on close co-operation of Federal and State agencies and the farmers, leaves little to be desired. Both the organisation and the technique of artificial control are being continually perfected, and it is estimated that, on the average, each dollar spent on grasshopper control serves to save crops to the value of 35 dollars. This is a remarkable achievement, and a large share of credit for it belongs to the Division of Grasshopper Control, admirably organised and run by Dr. Claude Wakeland and his staff. Nevertheless, it is clear that the protection of crops by direct control methods cannot be relaxed, and efforts on an ever-increasing scale will have to continue indefinitely. The policy of direct control is a palliative which cannot lead towards a lasting solution of the grasshopper problem in the North American continent.

This state of affairs has been realized by entomologists of the United States and Canada for some time, and their views were forcibly expressed in the following resolution adopted at a session of the Committee on Grasshopper Research at Lincoln, Nebraska, in 1946: "Millions of dollars have been appropriated and spent during the past twenty years by state, provincial, federal and dominion agencies for materials and labour for the applied control of grasshoppers. During the same period, the amount of money spent on research for a solution of the grasshopper problem has been woefully inadequate.

We are convinced that each million dollars spent on grasshopper research now will save hundreds of millions to the people of the United States and Canada in future emergencies." The Lincoln Conference elaborated a programme of research and recommended that such research should be co-ordinated for the whole continent by a permanent Committee on Grasshopper Research of the American Association of Economic Entomologists, through a 'research co-ordinator' whose duty it would be to stimulate research, to assist it and to ensure the co-operation between different research agencies. The important practical question of establishing and financing the 'co-ordinatorship' remained, however, unsolved.

The next session of the Committee on Grasshopper Research was held at St. Paul, Minnesota, in March 1947, and I had the privilege of taking part in the discussions. Afterwards, I was able to visit several of the most important centres of grasshopper research in the United States and Canada and to study their work on the spot. The impressions gained during this short visit may have been incorrect, and are certainly incomplete; but they are of considerable general interest as an illustration of a research policy diverted from its ultimate objective by temporary influences.

All programmes of grasshopper research both in the United States and in Canada are dominated by the need to produce immediate practical results, on which year-to-year financing of research depends. Therefore, two items of research are in the foreground. One is the testing of new insecticides, which are continually appearing on the market. Little fundamental research on insecticide action is in evidence, but purely empirical evaluation of effectiveness and cost take a vast amount of time and energy of research workers. It was somewhat disconcerting to see almost the whole entomological staff of the Federal Grasshopper Research Section occupied for weeks in carrying out field-tests of new insecticides, without any technical assistants or labour. The explanation was the very high cost of labour; but the use of qualified research workers for actual field operations appeared a very questionable measure of economy.

The second problem absorbing research workers is grasshopper survey. Systematic surveys of grasshopper populations were introduced more than ten years ago, and since then three annual surveys (nymphal, adult and eggs) are carried out regularly over all States subject to infestation. Survey methods, sampling technique and the analysis of the data are very elaborate and are standardized throughout, so that, theoretically, one would expect the surveys to produce a vast accumulation of data of great value for an analysis of population trends and the factors regulating populations. Unfortunately, the surveys are primarily intended to provide a statistical basis for the assessment of the expected infestation and for the calculation of quantities of control materials. The value of the survey data for population studies is undoubtedly very great; but the execution of surveys and purely statistical computation of their results appear to occupy practically the whole time of the survey personnel. It was instructive to see how an admirably conceived and perfectly organised machinery for collecting scientific data of great value has enslaved its creators and has made it almost impossible for them to do anything beyond routine work. The amount of the accumulated data is now so great that it would take a team of research workers several years to analyse this material. There is no doubt that such an analysis would provide information on the sources of grasshopper outbreaks and on the factors controlling them; this information would form a basis for formulating a long-range policy directed towards a lasting prevention of grasshopper outbreaks, instead of annual campaigns achieving only temporary relief; but it is apparently very difficult to make the administration realize the need for any expenditure that does not promise immediate return.

The soundness of the idea of grasshopper prevention was freely admitted by American and Canadian colleagues, but they were clearly of the opinion that, under present conditions, it would be futile to contemplate such a policy, which requires planning and execution on a continental scale. This close dependence of an entomological problem on the social structure of the country is most strikingly illustrated by the example of the grasshopper situation in the Phœnix valley of Arizona. It is a wide irrigated plain where cotton cultivation prevailed in the past; but during the Second World War a rise in the price of alfalfa seed caused a great extension of the latter crop. Irrigated alfalfa fields in a semi-desert climate of Arizona provided ideal conditions for *Melanoplus mexicanus* and enabled it to produce up to three generations in a year instead of the normal one. A most serious infestation by this species has developed, and repeated applications of control methods are required to save the crop. Even a cursory examination of the area has suggested that some less well-cultivated fields, with patches of grass, may be the sources of infestation, and a general application of certain cultivation methods may have a far-reaching effect. The possibility of this approach was admitted, but it was pointed out that it will never be possible to induce all growers of alfalfa to adopt improved methods, particularly because in that area the cultivation of alfalfa on such a large scale is due mainly to the high and possibly only temporary profits. Should the price fall, alfalfa will be abandoned in favour of another crop. Under such conditions, any long-range policy is useless to contemplate, and palliatives must continue to be employed. Sooner or later, they may become too costly in relation to the crop value, and the problem of long-range prevention will inevitably arise. It might be a sound policy at least to commence research in that direction before the crisis becomes acute; but it does not appear possible to expect that the necessary funds would be obtainable for a long-range research which does not promise an immediate profit.

Apart from the enforced wrong emphasis in the research programmes, they suffer from a lack of co-ordination. A striking fact is that although certain grasshoppers, notably *Melanoplus differentialis*, are very extensively used in universities as laboratory animals, such research as is carried out in universities is entirely disconnected from field-work executed by the federal grasshopper research agencies, by experimental stations and by the agencies engaged in grasshopper surveys. At the meetings of the Committee on Grasshopper Research, university research workers were conspicuous by their absence, with very few exceptions. As a result, field investigators are often very backward in their approach to the problem, while university workers do not know of the existence of a large number of problems of grasshopper biology which arise in the field but can only be solved in the laboratory.

The need for co-ordinating all grasshopper research has been repeatedly stressed by the Committee on Grasshopper Research, but the impression was that this is an aspiration rather than a demand for a practical measure. It would be natural to suggest that co-ordination of grasshopper research might be organised, or at least financed, jointly by the Governments of the two North American countries, but somehow this appeared to be impracticable.

In spite of all handicaps, American entomologists are making great strides in the study of the grasshopper problem. Unfortunately, their achievements are insufficiently known, since surprisingly little has been published on the subject, mainly because the routine work leaves no time for analysing and summarizing the results. It was even more surprising to hear that many important papers have been ready and waiting for publication for some years. Lack of funds as an explanation did not sound very convincing for a European visiting the United States. The Committee on Grasshopper Research has passed a very strong recommendation that the analysis of accumulated data and the publication of results should be speeded up; but it remains to be seen what the official reaction will be.

It is impossible here to discuss details which would be of interest only to specialists, who have a great deal to learn from the experience of American colleagues, particularly with regard to the technique and the organisation of grasshopper control. A much wider interest is attached to the general aspects of the North American grasshopper problem and its treatment. There is no doubt whatever that the problem is a man-made one, and it reached its great economic importance as a result of land development which was rapid, extensive and unscientific. A rapid expansion of unplanned agriculture in the North American continent has created exceptionally favourable conditions for various insect pests and for grasshoppers in particular. An analogous situation is rapidly developing in Australia, and it is only a matter of time before Africa will be faced with similar results of extensive agricultural development. There is in Africa a vast and varied grasshopper fauna, many members of which will undoubtedly develop into dangerous pests as soon as suitable soil conditions and abundant food are provided for them by the clearing of forests and by mechanized agriculture. At present, African development is threatened by locust plagues, which are a serious factor, but a periodical one; grasshopper plagues, although less spectacular than locust invasions, will be much more serious in their aggregate effects because they tend to be perennial, as the example of North America shows. Anti-locust policy in Africa is developing on the lines of prevention, and it became possible to formulate such policy only after some twenty years of international research. It will take a long time to study the possible effects of mechanized agriculture on native grasshoppers, and it is therefore not too early to consider commencing such studies. The alternative is to do nothing until the danger becomes imminent, by which time it may be too late for any measures of prevention, and perennial artificial control will be required. Again, the American example shows that such control is very expensive and only highly remunerative crops can stand the cost. Agricultural development of Africa is now being planned on a vast scale, and it may be wise not to forget possible handicaps.

ATMOSPHERIC TURBULENCE

MANY workers in atmospheric turbulence probably believe the subject to be more readily capable of formal and exact development than some other branches of dynamical meteorology, a belief deriving from a certain measure of success already attained. But that this success is rather slight is evident when one considers that there is still only slight understanding of turbulence in isothermal flow such as occurs in wind tunnels, pipes, etc., while the atmospheric problems are complicated by the existence of buoyancy forces, positive or negative, by the earth's rotation, and, over the oceans, by the form of the surface being dependent on the air motion itself. Again, there is a very considerable difference in scale between laboratory and atmospheric flow; but this difference may well be ultimately profitable to an improved understanding of turbulence on all scales—solar, terrestrial (atmospheric and oceanic), and laboratory.

G. I. Taylor effectively established the subject of atmospheric turbulence in his classical paper of 1915. From observations of temperature on the Eiffel Tower and by kite over the Newfoundland Grand Banks, and from Dobson's observations of wind speed and direction in the first kilometre or so over Salisbury Plain, Taylor deduced that the turbulence of the lower atmosphere resulted in an effective coefficient of diffusion of heat or of momentum some 10^4–10^6 times greater than the value for molecular diffusion, the ratio increasing with the wind speed and the lapse-rate of temperature. The equations of heat or momentum transport by which these results were obtained were solved by assuming the turbulent diffusivity constant through the layer concerned, whereas on any simplified picture of eddy motion a variation with height appeared probable; and this variation was involved in the next major advance in the subject early in the last decade. The advance was derived from Prandtl's application of mixing-length ideas growing out of earlier work by Taylor and Schmidt, the mixing-length being an analogue in eddy motion of the mean free path of molecular theory and connoting the mean length of path over which turbulent elements move between birth and extinction, that is, between acquiring and losing a velocity different from that of the mean motion at the levels in question. Prandtl assumed that near a boundary the mixing-length increased linearly with distance from the boundary, and by assuming further that the turbulent elements conserved their momentum during motion (that is, pressure field of no immediate consequence) he deduced that the mean velocity should increase with the logarithm of the distance from the boundary in the region of negligible variation of turbulent shearing stress. This result was in accord with observations in the laboratory for a very wide range of Reynolds number, and in the first 10 m. or so of the atmosphere when in near-neutral static equilibrium. The mixing-length distance relation, more or less confirmed by this agreement of theory with observation, implied that turbulent diffusivity increased linearly with distance from the boundary and was given directly, for momentum transfer at least, from observations of the velocity profile.

Early in the 1920's, L. F. Richardson had examined the effect of static stability on the rate of growth or decay of turbulence. He showed that the rate of production of turbulent energy due to a velocity

gradient would compensate the rate of decay due to the work done by eddies against (negative) buoyancy forces, provided the ratio of the square of the vertical gradient of mean velocity to the difference between the adiabatic and actual lapse-rates of mean temperature exceeded a certain critical magnitude. This criterion is only now receiving the attention and application which it merits.

It is to be noted that the above achievements are expressed in the main in terms of the bulk properties of the medium (mean speed and gradients of mean speed and of temperature, etc.), a desirable feature for a ready assessment of the diffusive properties of a given field of mean flow, but inadequate for an understanding of the mechanics of turbulence. Progress in the latter has been rather slight, though much experimental work has been done in the wind tunnel on the measurement of turbulent energy and of its spectrum, and on the correlation between various turbulent velocity components. This has been allied with a promising theoretical treatment of the statistical mechanics of isotropic turbulence, initiated by Taylor in 1935. A little knowledge has been gained of the statistics of atmospheric turbulence in the lower atmosphere, notably by Giblett, Scrase and Best in Great Britain, but there is very little information for the free atmosphere.

This was the background against which the Geophysical Discussion at the Royal Astronomical Society on "Atmospheric Turbulence" was held on October 24. Prof. O. G. Sutton opened the discussion by stressing the alternative approaches to the subject, the approach through the study of bulk properties on one hand and through the study of the internal structure of the fluid on the other, recapitulating the history of the subject and some of the more readily observed characteristics of atmospheric turbulence in illustration. A potentially profitable approach on the structural side was made by Taylor in 1922 in providing a relation between the diffusion of an entity and the correlation between the eddy velocities of a given element of fluid at increasing intervals of time. Sutton developed this treatment by an empirical formulation of the correlation coefficient (direct observations of the correlation coefficient would be very difficult and an *a priori* derivation presupposes a basic understanding of turbulence), and he deduced the rate of transfer of matter (evaporation) from a plane boundary in a turbulent flow, obtaining good agreement with observations for both matter and heat transfer in the laboratory for aerodynamically smooth flow, that is, flow in which the molecular viscosity is responsible for momentum transfer at the boundary itself. This treatment remains to be generalized for aerodynamically rough flow, that is, flow in which the geometrical roughness of the boundary is a controlling factor, and for an atmosphere statically stable or unstable. Sutton also pointed out some of the major meteorological problems of a larger scale requiring investigation and solution, such as the temperature and humidity distribution in the layer which is responsible for the propagation of short radio waves over the earth's surface (see *Nature*, **157**, 860; 1946), and the structure and distribution throughout the troposphere of gusts which on occasion may be a serious hazard for aircraft.

Prof. P. A. Sheppard spoke of his simultaneous measurements of surface drag and the accompanying velocity profile in the air. In the laboratory the mean velocity u at distance z from a boundary is related with the drag τ_0 at the boundary by

$$u = \frac{(\tau_0/\rho)^{1/2}}{k}\left[\log_e\left\{\frac{(\tau_0/\rho)^{1/2}z}{\nu}\right\} + 1{\cdot}75\right]$$

. . . aerodynamically smooth flow,

or

$$u = \frac{(\tau_0/\rho)^{1/2}}{k}\log_e\left(\frac{z}{z_0}\right)$$

. . . aerodynamically rough flow,

where k (about 0·40) is the constant of proportionality between mixing length and distance referred to above, ρ is the fluid density, ν the kinematic viscosity and z_0 a length characterizing the roughness of the boundary. For either type of flow the turbulent diffusivity $K\left(=\frac{\tau_0/\rho}{du/dz}\right)$ is given by

$$K = (\tau_0/\rho)^{1/2}\,kz,$$

where τ_0/ρ may be obtained from observations of the velocity at two heights. Sheppard's observations were made to determine whether the same relation between profile and drag held in the lower atmosphere, or, alternatively stated, to determine the value of k there. The result, for a moderately unstable atmosphere, was $k = 0{\cdot}45$, in very reasonable agreement with the laboratory value in view of the instability which would enhance k. There was also found to be a significant departure from linearity between mixing-length and height in the sense of larger mixing-lengths at the upper levels of observation—again reasonable in view of the instability arising from buoyancy. Correspondingly, one might expect a departure from linearity in the opposite sense in stable conditions. Such departures must be reflected in corresponding departures from the logarithmic profile of wind velocity. Further, if the mixing-length is the same for any entity diffusing vertically, the profile of that entity should show a variation with stability (Richardson's Number is likely to be the relevant parameter) similar to that for wind velocity. Evidence of such variation was shown in the profiles of wind speed, temperature and vapour pressure obtained by various workers in the first 15 m. or so of the atmosphere; entities increased or decreased less rapidly than the logarithm of the height in unstable conditions, and more rapidly than this in stable conditions. Such profiles imply that the turbulent diffusivity increases more rapidly than the height in unstable conditions and less rapidly than the height in stable conditions. Up to what level these relations apply is not yet known—the increases cannot continue indefinitely.

Mr. F. Pasquill spoke on turbulence in agricultural meteorology and dealt first with the loss of water from soil and crops by turbulent diffusion. If the diffusivity for matter is the same as for momentum, the former is immediately deducible from a velocity profile; and the rate of evaporation E in a steady state (vertical flux of water vapour independent of height) is then obtainable from the vertical gradient of specific humidity $q(E = K/\rho.dq/dz)$. Pasquill's results from observations of the velocity and humidity profiles in the first 2 m. over grass gave quite encouraging agreement with the loss of water determined by soil sampling before and after the profiles had been determined, though the results of the soil sampling were a little ambiguous. Another agricultural application related to the dispersal of wind-

borne spores, a problem first tackled by Schmidt many years ago. The spores are dispersed by turbulence as they travel down-wind and are simultaneously deposited on the ground due to fall under gravity—a procedure analogous to the transport of silt in a river or estuary. Pasquill has calculated the rate of deposition at various distances down-wind of the source under given conditions, and obtains quite reasonable agreement with the rather meagre experimental data available.

Mr. K. L. Calder presented some very striking evidence of the applicability of Prandtl's expression for the eddy diffusivity in an isothermal boundary layer to the problem of the diffusion of gas and smoke emitted into the atmosphere near the ground along a line normal to the wind direction. The treatment takes account of the roughness of the underlying surface and gives excellent agreement with a large number of observed concentrations of gas and smoke.

Mr. E. L. Deacon showed a slide of velocity gradients, taken between 2 m. and 4 m. at a given site in various wind speeds and static stabilities, plotted against the Richardson Number for the same height-interval and times of observations. The high correlation shown gave strong support to the growing realization of the importance of Richardson's parameter in atmospheric turbulence.

The 'structural' approach to the study of atmospheric turbulence, either in terms of Prandtl's mixing-length or of Sutton's application of the Taylor correlation coefficient, has been essentially empirical. The mixing-length as used by Prandtl is indeed an idealized concept corresponding to no measurable property of the turbulence itself; it is rather a parameter with the dimension of length which appears from a suitable transformation of the turbulent flux equation. Sutton ascribed the difficulty of developing an *a priori* treatment of turbulence to the non-linear form of the Navier–Stokes equations and saw little hope of overcoming this difficulty, but Mr. G. K. Batchelor ended the discussion on a more hopeful note. He instanced the appreciable success of the fundamental theory launched by Taylor in 1935 to deal with the correlations between eddy velocities at points across and along the direction of mean flow when the turbulence is isotropic, and with the decay of such turbulence in a free stream. The theory is still in vigorous development, and may be expected, sooner or later, to provide better understanding of atmospheric problems.

P. A. SHEPPARD

NEWS and VIEWS

Students in British Universities

IN NATURE of December 6, in the course of an article on "University Expansion in Great Britain", a statement is attributed to Lord Simon to the effect that the output of arts graduates has risen more rapidly than that of science graduates, due to relatively greater ease of expansion on the arts side. Against this remark should be set the figures for university 'populations' given in a written answer by Sir Stafford Cripps in the House of Commons (*Hansard*, House of Commons, December 1). The total number of full-time students at university institutions in Great Britain for the autumn term 1947 was 76,764, compared with 50,246 for the academic year 1938–39. Analysing these totals by faculties, the figures for arts students were 34,200 and 22,512 respectively. The figures under pure science are 14,520 for 1947 and 7,767 for 1938–39; and an approximate doubling is also shown under technology (10,143 and 5,288) and under agriculture (2,337 and 1,043). Thus, whatever may be the present position with regard to the employment of arts graduates, the actual numbers of students in the arts faculties and in the science and technological faculties now in British universities have increased by about the same numbers since 1938–39, namely, 11,688 and 12,902 respectively; but whereas this represents an increase in the arts faculties of 52 per cent, in the science and technology faculties the increase is 91·5 per cent.

Some interesting figures are also given regarding the numbers of students now at the various universities of Britain as compared with the figures for the year 1938–39. Taking the larger universities only, they are as follow, the number in parenthesis being that for the last pre-war year: Birmingham, 2,975 (1,433); Bristol, 1,902 (1,005); Cambridge, 6,943 (5,931); Durham, 3,773 (1,709); Leeds, 2,888 (1,757); Liverpool, 2,943 (2,055); London, 15,789 (13,191); Manchester, 4,632 (2,462); Nottingham, 1,679 (582); Oxford, 7,500 (5,023); Reading, 990 (584); Sheffield, 1,670 (767); Wales, 4,654 (2,779); Aberdeen, 2,007 (1,211); Edinburgh, 4,904 (3,205); Glasgow, 7,073 (4,690); St. Andrews, 1,811 (928). The increases have thus been well spread over the whole country, though the biggest percentage increases are shown by some of the smaller institutions.

Annals of Botany: Prof. V. H. Blackman

READERS of the *Annals of Botany* will have seen with an element of regret that since September 30 Prof. V. H. Blackman has ceased to be editor. Prof. W. H. Pearsall, who succeeds him, is pre-eminently well qualified to do so, and as former editor of the *Journal of Ecology* is well known to many botanical authors. It is, however, fitting to record the very great debt which the botanical world owes to Prof. Blackman who, for more than twenty-five years, has borne with equanimity, kindliness and wisdom the editorship of one of the most influential botanical journals in the world. Almost every working botanist in Great Britain, and many from overseas, have at some time in their lives come under his influence, and the blue pencil has always been administered so graciously that a permanent friendship with the author has generally resulted in spite of compulsory improvement to literary style. It is greatly to be hoped that Prof. Blackman's influence on botany as a whole, and on younger botanists in particular, will continue to be felt for many years in other ways after the very considerable burden of the editorship has been lifted from him.

Sir Evelyn Shaw, K.C.V.O., and the Exhibition of 1851 Scholars

AN interesting informal gathering took place at the offices of the Royal Commission for the Exhibition of 1851 on December 5. A number of former '1851' scholars made a presentation to Sir Evelyn Shaw,

who has recently retired from the post of secretary after forty-three years' service with the Royal Commission. Since the awards were inaugurated in 1891, there have been more than five hundred scholars from Great Britain and all parts of the Empire. Most of them have studied in Great Britain and have been grateful for the friendly help given to them by Sir Evelyn Shaw. The presentation consisted of an album containing the signed photographs of 330 'old scholars' from all parts of the world, and a gold coin, dated 40 B.C. and bearing the portraits of Marc Antony and the young Octavius, chosen by Sir Evelyn for his collection. Sir Robert Robinson, chairman of the Science Scholarships Committee of the Royal Commission, and himself a former '1851' scholar, was unavoidably prevented from being present, and sent a goodwill message. The presentation was made on behalf of his fellow scholars by Prof. E. N. da C. Andrade, who expressed the esteem and affection felt for Sir Evelyn by all who had come into contact with him.

Trees and Shrubs as Animal Fodder

THE extent to which animals are dependent on shrubs and trees for fodder is probably not fully realized by those accustomed to associate grazing with true grass or grass–legume pastures, ranges or steppes. The information, however, provided in Joint Publication No. 10, "The Use and Misuse of Shrubs and Trees as Fodder", published by three of the Imperial Agricultural Bureaux (Pastures and Field Crops, Forestry, and Animal Nutrition, respectively) leaves no doubt as to the magnitude of the subject. Over large areas, particularly those with semi-arid climates, in Australia, Africa, India, the U.S.S.R., United States of America and lands in the Mediterranean region, woody plants provide the chief source of food for the numerous low-grade animals kept for the wool, hides and even meat they produce. Most of these regions suffer from gross over-stocking, with a resultant deterioration in the vegetative cover, which in its turn gives rise to serious soil erosion. The problems are numerous, and their solution by no means similar in different parts of the world; but the breeding of better-class animals and a reduction in their numbers should both check the soil erosion and make it economically advantageous to grow improved types of fodder. The best type of management of shrub-tree associations has yet to be found. Experiences with restricted seasonal grazing, reclamation work by re-seeding, and direct shrub cultivation are described and the problems of forest grazing discussed. Bush encroachment on grazing land offers serious difficulty in some countries, and various control measures are being tried for the eradication of undesirable species. As regards nutritive value, the chemical composition and digestibility of some thousand samples of shrubs and trees are tabulated; it is significant that, compared with grassland, the values fluctuate little with season, so that they are of special value in times of drought when indigenous grasses are at their lowest nutritive level. The publication, which contains seventy illustrations, can be obtained from the Imperial Agricultural Bureaux, Central Sales Branch, Penglais, Aberystwyth, Great Britain (9*s*. net).

Agriculture in Northern Ireland

IN 1943 an Agricultural Enquiry Committee was set up to report on the future of agriculture in Northern Ireland, and interim reports on transport and rural housing appeared in 1943 and 1944. The full report has now been published (H.M. Stationery Office. 3*s*. 6*d*. net) and is divided into five main sections, dealing respectively with agricultural policy and production, marketing and processing, education and research, services ancillary to agriculture, and social conditions and the agricultural community. In view of its geographical position and climate, concentration on the production of livestock and livestock products is recommended as a long-term policy. Closely correlated with this is the need for improvement in the grassland, and to carry this out, the establishment of an experimental farm in County Fermanagh is suggested, and the periodic breaking up of the pastures strongly advocated. As regards marketing, the Committee is of the opinion that the Government should continue its policy of guaranteed prices for all major farm products, such prices being based on those considered necessary to call forth the production required, the Exchequer bearing the cost of any subsidies that may be needed. Considerable reorganisation is proposed in the sphere of education, while as regards research, investigations on the nutritive value of grassland, animal breeding and veterinary problems are of special importance to bring the work into line with the general agricultural policy outlined above. Adequate ancillary services are an essential feature, and attention is directed to the need for a satisfactory system of land tenure, and better electricity and water supplies, drainage and sewage schemes. The concluding section of the report puts forward a proposal for the establishment of a Central Agricultural Council, based on existing organisations, which should act as a corporate body for the promotion of the welfare of the agricultural industry and the improvement of social conditions for the rural population.

The Scottish Plant Breeding Station

THE twenty-sixth annual report of the director of the Scottish Society for Research in Plant Breeding provides much evidence of the value of research for agriculture. The Society is in a healthy state, having received a large number of subscription members during the year. New varieties of oats, barley, swedes, grasses and kales are either in commerce or will shortly be released. Three lines of work at the Station are of particular interest. The investigations upon virus diseases and blight of the potato have reached the stage at which the breeding of immune or resistant varieties may be directed. Dr. Gregor has shown that local races of grasses are often of considerable value as source material for breeding in the same way as the ancient local strains of oats and barley were of advantage in the eighteenth century. The genecological studies originally made upon *Plantago* are therefore bearing fruit in agriculture. The director, Mr. W. Robb, has been selecting suitable strains from among more than 15,000 hybrids of oats with the view of combining stiff straw, and freedom from lodging, with high yields. As the result of negotiations between the Society and other bodies it will be possible to enlarge the grounds and the activities in the near future.

An Electric Heater for Flasks

AN electric 'mantle' for the heating of flasks, termed an 'Isomantle', has recently been introduced into Great Britain by Messrs. Towers and Co., Ltd., of Widnes. It consists essentially of a tough, double-walled, glass-cloth shroud, hemispherical in shape and carrying a

nichrome/glass-cloth heating-element in close proximity to the inner wall. A packing of glass-wool provides efficient thermal insulation, and the whole unit is carried in a neat aluminium cradle which may either be placed directly on the bench or supported by a retort stand. Temperature is regulated by a series resistance or, more effectively on an A.C. supply, by a device named the 'Simmerstat', which gives continuous and accurate control of heat from zero to a maximum sufficient to boil liquids at 300–350° C. Laboratory tests show that an 'Isomantle' provides a really safe and efficient method of heating liquids, particularly for operations such as routine solvent extraction. Flask breakage will be reduced to a minimum, and the large heating-area promotes uniform boiling. Deliberate efforts to induce the 'bumping' of boiling liquids were quite unsuccessful. A range of sizes from 100 to 5,000 ml. is being prepared; it is to be hoped that the manufacturers may eventually find it possible to 'tailor' jackets of other shapes for special purposes.

Research in the Jewellery Industry

THE first annual report of the Design and Research Centre for the Gold, Silver and Jewellery Industries has been issued (Goldsmiths' Hall, Foster Lane, London, E.C.2); the Centre was inaugurated on October 1, 1946. After referring briefly to the initiation of market and consumer research, the training of designers, including the provision of refresher courses and the plans for development of the library and reading room and information service, the report deals with the plans of the research section. Prof. R. S. Hutton was originally appointed honorary acting director of research, and an Advisory Research Committee has formulated a research programme and initiated investigations on tarnish-resisting silver at the Metallurgical Laboratory, University of Cambridge, and on polishing processes, temper-hardened silver, coloured patina and other metal finishes at the Sir John Cass Institute, London. Dr. C. E. Garden was appointed director of research and took up his duties on June 2, 1947, and an industrial liaison officer has also been appointed. An information bulletin is being issued, and a research laboratory is being established at Goldsmiths' Hall, London.

Californian Academy of Sciences

IN the annual report of the Californian Academy of Sciences for the year ending December 31, 1946, the president refers to the decision of the trustees to proceed with a campaign for raising funds which will make possible the construction of a planetarium adjacent to the Academy's buildings in Golden Gate Park. It is also planned to build an addition to the African Hall, an auditorium and additional housing to relieve the over-crowding of several of the departments. The director, Dr. R. C. Miller, refers in his report to the resumption of field-work by nine members of the Museum staff, who made eleven field trips to points ranging from Newport, Oregon, to Acapulco, Mexico, and from the seashore to the High Sierra. Many accessions to the departmental collections were made during the year, and the director reports briefly on the work of the Academy's Committee of Latent Natural Resources, established in January 1942, to organise research relating to the existing national emergency. The work of the Committee was carried on chiefly by correspondence; the Committee has had a leavening influence far beyond the range of its immediate activities, which included the location of strategic minerals, the resources of the sea for war-time economy, black glass for mirrors for navigating instruments and tuna fisheries. The Committee is being retained as a stand-by committee for consultation on similar problems as need may arise.

University News

A CHAIR of genetics is to be established in the Faculty of Science, University of Birmingham.

Mr. Charles R. Morris, formerly fellow of Balliol College and later Under-Secretary at the Ministry of Production, has been nominated as vice-chancellor of the University of Leeds in succession to Dr. Mouat Jones, who retires on October 1, 1948.

Mr. R. L. Goodstein, lecturer in mathematics in the University of Reading, has been appointed professor of mathematics in University College, Leicester.

Dr. F. E. King, lecturer in chemistry in the University of Oxford, has been appointed Sir Jesse Boot professor of chemistry in University College, Nottingham.

Announcements

WE regret to announce the deaths of Earl Baldwin of Bewdley, K.G., P.C., F.R.S., on December 14, aged eighty; Dr. Charles Bolton, C.B.E., F.R.S., consulting physician to University College Hospital, London, on December 6, aged seventy-four; and the Right Hon. Lord Rayleigh, F.R.S., on December 13, aged seventy-two.

PROF. A. E. MUSKETT, professor of mycology and plant pathology in the Queen's University of Belfast, has been elected president for 1948 of the British Mycological Society.

The Atomic Scientists' News, the journal of the Atomic Scientists' Association (limited by guarantee), issued approximately monthly, has hitherto only been available to members of the Association. To enable libraries and institutions, and other individuals who do not wish to join the Association, to obtain copies, a subscription scheme has been started. The subscription is 10*s.* 6*d.* a year, and further particulars are obtainable from the editor, Dr. C. H. Westcott, Physics Department, University, Edgbaston, Birmingham, 15.

THE international journal of cytology *Chromosoma* was founded by Dr. Hans Bauer, of the Kaiser-Wilhelm Institut für Biologie in Berlin Dahlem, in 1939. It completed its second volume during the War, the last issue appearing in 1944. Its publication has been resumed by the Springer-Verlag, now in Vienna, with a double number (Volume 3) dated August 1947. This number contains papers by Seiler, Geitler, Le Calvez, Schrader and others on many aspects of chromosome behaviour in plants, animals and protista.

AN exhibition, "Highways of the Air", is being arranged by the Royal Geographical Society, in co-operation with the Ministry of Civil Aviation, the British Airline Corporations and the Ministry of Education, at the Society's house in Kensington Gore, London, S.W.7, during December 22–January 15; it will be open from 11 a.m. to 5 p.m. on weekdays (except Christmas Day and Boxing Day) free of charge. The exhibition has been planned against the background of the air-age geography and the development of civil airways.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Electron Microscopy of Bacteria

BACTERIA have usually been prepared for observation in the electron microscope by growth in liquid media, a drop of the suspension being allowed to dry on a collodion-covered specimen grid. Smiles[1] has employed an adaptation of the impression technique used in optical microscopy for obtaining material from a surface culture: a glass slide pressed on to the agar removes a film of bacteria, which is allowed to dry partially, and then removed by stripping with a collodion film. Hillier and Baker[2] have described a more direct method, in which the collodion film is formed on the agar surface and then floated off in water. Unfortunately, most bacteria, however mounted, prove to be too opaque to an electron beam of the energy usually employed (50–60 kV.) to show appreciable internal structure.

In studying the morphology of avian tubercle bacilli, which, in certain stages of development, we find to be less dense to electrons than most bacteria, we found it impossible to strip them from the Löwenstein and blood-agar surfaces on which they are normally grown. Two methods have been devised by which intact films can consistently be obtained. In the first, a thin coating of glycerine-agar is spread on the surface of the Löwenstein medium and the bacterial inoculum placed on this. After sufficient growth has developed, a 1 per cent solution of collodion is flowed over the surface, allowed to dry, and removed by immersion in water. Alternatively, a square of the Löwenstein medium, at the required stage of growth, is inverted and the surface pressed firmly for a few seconds on to a glycerine agar surface, so that the culture is transferred from the one to the other. It may afterwards be removed from the latter as before by stripping on a collodion film. In either case the specimen grids are then placed on the stripped film, and both removed and mounted in the usual way. The resulting electron micrographs show a richness and clarity of internal structure not otherwise obtainable (Figs. 1–4). Before spreading the collodion film on the culture, it is fixed by exposure for 5 min. to the vapour of 2 per cent osmic acid. As a further precaution against infection, a 5 per cent solution of formalin is employed for floating off the collodion films, which are then washed in distilled water before mounting. Fixation in formalin vapour proved unsatisfactory in that the films could not afterwards be stripped at all.

An interpretation of the results obtained at different stages in the life of a culture will be published elsewhere.

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[1] Smiles (demonstrated to the third Electron Microscope Conference, National Institute for Medical Research, London, June 1945).
[2] Hillier and Baker, *J. Bact.*, **52**, 411 (1946).

A New Isotope of Tungsten

A SEARCH for tungsten radio-isotopes was made using a 5-mil tantalum foil which had received 80 micro-ampere-hours bombardment with approximately 20 MeV. deuterons from the 60-in. Crocker Laboratory cyclotron. The foil was dissolved in nitric acid containing five per cent of hydrofluoric acid. A few milligrams of tungsten carrier was added, and after removal of hydrofluoric acid by fuming with sulphuric acid, the tantalum was precipitated by sodium hydroxide and the precipitate digested with hot alkali. Tungsten was precipitated from the alkaline solution by boiling with excess nitric acid. The procedure was repeated until the tantalum-scavenging carrier precipitates were inactive.

The tungsten fraction contained a previously unreported, single radioactivity of half-life 140 ± 2 days, emitting electrons, X-rays and gamma-rays. The radiations were studied using aluminium, beryllium and lead absorbers, measurements being made with an 'end-on' type Geiger–Müller counter with a 2·7 mgm./cm.² mica window, and filled with 10 cm. argon and 0·5 cm. alcohol. The radiations had the following characteristics.

(1) Electrons of range ~ 11 mgm./cm.², corresponding to an energy of about 90 keV. The range was determined by resolution of the aluminium absorption curve (Fig. 1) and by direct measurement using thin beryllium absorbers. The absorption of the soft X-ray background was measured in aluminium after removal of electrons by a 14 mgm./cm.² beryllium absorber.

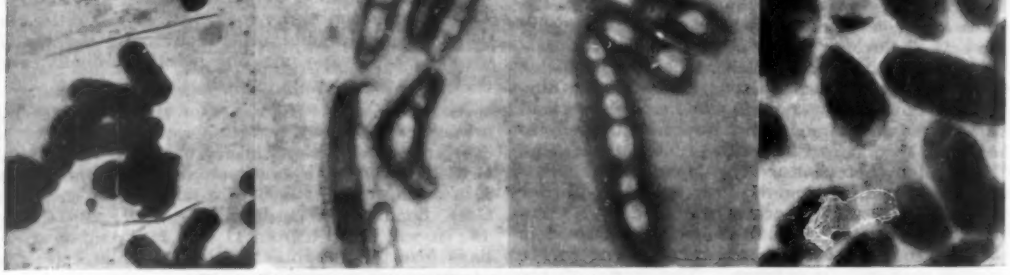

Fig. 1. INOCULUM OF AVIAN TUBERCLE BACILLI, FROM A CULTURE FOUR WEEKS OLD
Figs. 2 and 3. INTERMEDIATE FORMS AFTER 24 HOURS AND THREE DAYS INCUBATION ON LOEWENSTEIN MEDIUM
Fig. 4. FORMATION OF DAUGHTER RODS AFTER FOUR DAYS. × 15,000

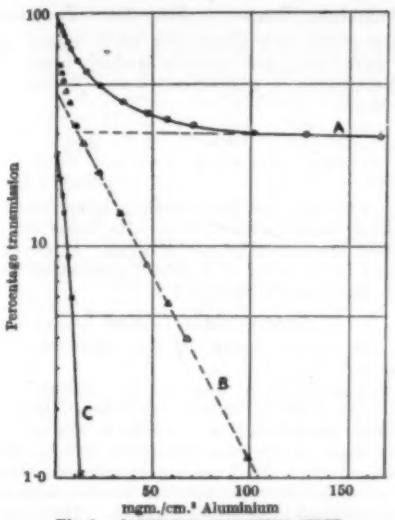

Fig. 1. ALUMINIUM ABSORPTION CURVE
A, *K* X-ray and γ-background; *B*, *L* X-rays, half-thickness 17 mgm./cm.²; *C*, electrons range ~ 11 mgm./cm.²

(2) Electromagnetic radiation of half-thickness 17 ± 1 mgm./cm.² aluminium, 124 ± 4 mgm./cm.² lead and 15 ± 0·4 gm./cm.² lead, corresponding respectively to energies of 8·7 keV., 59 keV. and 1·83 MeV. The lead absorption of the two harder components is shown in Fig. 2.

The ratio of electrons to quantum radiation was determined for an 'infinitely thin' sample mounted on a mica slip of mass thickness 0·6 mgm./cm.². Making corrections for counting fluctuations, for absorption in the counter window, air gap, etc., and assuming equal counting efficiencies of 1 per cent for the 59 keV. and 1·83 MeV. rays, with an efficiency of 3·3 per cent for the 8·7 keV. ray, the following ratios were obtained: Electrons : 8·7 keV. ray : 59 keV. ray : 1·83 MeV. ray = $2 \times 10^{-3} : 1{\cdot}0 \pm 0{\cdot}1 : 1{\cdot}0 : 1{\cdot}0 \pm 0{\cdot}2 \times 10^{-3}$.

The sample was further investigated using a crude β-ray spectrometer, measurements being made with fields up to 16,000 gauss/cm. No positrons or electrons of energy greater than 100 keV. were observed, but only a single peak of electrons. The peak value (Fig. 3) corresponds to an electron energy of 70 ± 2 keV.

The allocation of the isotope to mass 181, and the assumption that it is formed by a (*d*,2*n*) reaction in

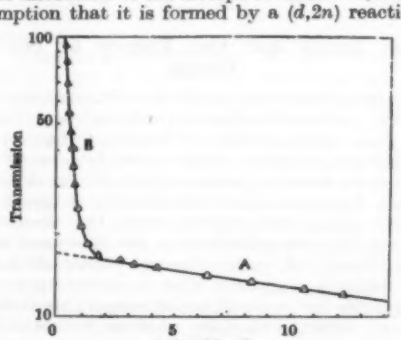

Fig. 2. LEAD ABSORPTION CURVE
A, γ-ray, 15 gm./cm.² half-thickness, measured up to 46 gm./cm.² lead; *B*, *K* X-rays, half-thickness 124 mgm./cm.²

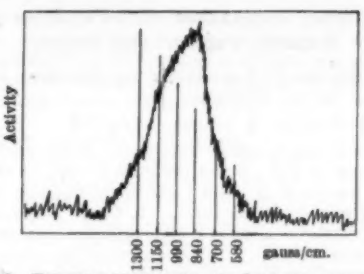

Fig. 3. ELECTRON DISTRIBUTION ON 'MAGNETIC COUNTER'

tantalum, seems reasonable. A single tungsten activity only, which has no tantalum daughter of half-life greater than a few minutes, has been found. The (*d*,2*n*) and (*d*,4*n*) reactions in tantalum only could lead to an active tungsten isotope, if the possibility of a long-lived isomer of stable W^{180} or W^{182} is excluded. The yield of the (*d*,4*n*) reaction with the 20 MeV. deuterons used would be too small by a very considerable factor to account for the observed activities. Further, no evidence of any isotope emitting X-rays was found in the separated tantalum fraction, which contained only the well-known 97-day Ta^{182}.

The measured half-thicknesses for the electromagnetic radiation agree well with the values of 17·8 mgm./cm.² aluminium, and 128 mgm./cm.² lead calculated for the *L* and *K* X-rays of tantalum respectively, using data given by Compton and Allison[1] for the energies and intensity ratios of tantalum X-radiation. The radiations of the new isotope are thus compatible with the assumption of orbital electron capture in tungsten. The small fraction of disintegrations through the 1·83 MeV. gamma-ray and conversion electrons might be accounted for by transitions to metastable states in Ta^{181}. De Benedetti and McGowan[2] have observed a metastable state in Ta^{181} of 22 microsec. half-life produced in the beta decay of Hf^{181}. The radiations[2,3] consist mainly of electrons of ~ 110 keV. energy, and it was suggested that these were due to conversion of a 180 keV. gamma-ray in the *K*-shell. The excitation energy of the metastable level would be ~ 180 keV., with a transition to the ground state involving a probable spin change of 3 units, from $\frac{1}{2}$ to 7/2. The energy of the electrons observed in the decay of the new tungsten isotope agrees reasonably with that reported for the conversion electrons from Ta^{181*}, and corresponds to a 140 keV. gamma-ray completely converted in the *K*-shell. Since no 1·83 MeV. gamma-ray is reported in the disintegration of either Ta^{181*} or Hf^{181}, a further level above that of the 22 microsec. state must be assumed, with electron capture in W^{181} leading directly to each of the two states in approximately 1 per cent of the transitions.

Acknowledgment is due to Dr. T. G. Hamilton and the crew of the 60-in. cyclotron for assistance in bombardments, to Prof. G. T. Seaborg for his advice and criticism, and to the University of California for the use of its facilities.

G. WILKINSON

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[1] Compton, A. H., and Allison, S. K., "X-Rays in Theory and Experiment", 2nd Ed. (New York: Van Nostrand).
[2] De Benedetti, S., and McGowan, F. K., *Phys. Rev.*, **70**, 569 (1946).
[3] Madansky, L., and Wiedenbeck, M. L., *Phys. Rev.*, **72**, 185 (1947).

Primary Ionization of β-Particles in Alcohol Vapour and Argon

THE efficiency of a counter for detecting ionizing particles can be written

$$\varepsilon = 1 - \exp(-Spl/76), \qquad (1)$$

where S is the primary ionization of the particle in the gas at N.T.P., p the pressure in cm. of the contained gas at 0° C., and l the length of the path of the particle in the counter. T. Graf[1] has made use of this fact to measure the primary ionization of β-particles in air. Two counters were placed in a spectrograph so that all particles passing through the second counter had, of necessity, also passed through the first. If N is the rate of counting in the second counter and N_c the coincidence counting-rate, the efficiency of the first counter is given by

$$\varepsilon = N_c/N. \qquad (2)$$

A knowledge of l and p then enables S to be calculated from equation (1).

We have, by this method, investigated the primary ionization of β-particles in mixtures of argon and ethyl alcohol vapour. For a mixture, formula (1) can be written

$$\varepsilon = 1 - \exp\{(-S_1p_1 + S_2p_2)l/76\}. \qquad (1a)$$

S_1 and S_2 can be evaluated by determining ε for two different combinations of the partial pressures p_1 and p_2.

The experiment was performed for β-particles of one energy only, namely, 0·42 MeV., and the mean values obtained were 79·0 ion pairs/cm. in alcohol vapour and 29·8 ion pairs/cm. in argon. These are consistent with values of 68·7 ion pairs/cm. and 25·9 ion pairs/cm. respectively for β-rays of energy 1 MeV.[2].

The value for argon is in agreement with measurements made with fast cosmic rays[3].

Hazen[4], by plotting a curve of primary ion pairs/cm. against electrons per molecule for five gases and extrapolating, estimates a value of 33 ion pairs/cm. for alcohol vapour. By adding the measured values for C_2, $3H_2$ and $\frac{1}{2}O_2$, he obtains a value of 42 ion pairs/cm. On either basis the value obtained is considerably smaller than the value we have measured. Indeed, on theoretical grounds[5] the measured value of 69 ion pairs/cm. is only consistent with an effective ionization potential of 7–8 electron volts.

It is noteworthy that the efficiency of a counter containing alcohol vapour at 1 cm. mercury pressure measured by Rochester and Jánossy[6] suggests a value of at least 61 ion pairs/cm. for alcohol vapour.

If any single ion pair escapes detection in the argon-alcohol counters, the value of the primary ionization for alcohol vapour would be even greater than 69 ion pairs/cm. This type of counter is, however, likely to be 100 per cent efficient, in contrast with the slow types used in earlier work[1,7,8].

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Relations Between Structure-Factors

IF the edges of the unit cell of a crystal are all taken equal to 1, the electron-density function can be expressed as a three-dimensional Fourier series of the form

$$\rho(x,y,z) = \sum_{h=-\infty}^{\infty} \sum_{k=-\infty}^{\infty} \sum_{l=-\infty}^{\infty} F_{h,k,l} \exp\{2\pi i(hx+ky+lz)\}.$$

It is a commonplace of crystallography that X-ray diffraction methods can tell us the value of $|F_{h,k,l}|$ but never the actual phase of $F_{h,k,l}$. If we restrict ourselves to the case of a centro-symmetric crystal, we can take the F's real and so

$$F_{h,k,l} = \alpha_{h,k,l} \; |F_{h,k,l}|,$$

where the second factor on the right-hand side is known and $\alpha_{h,k,l} = \pm 1$.

Harker and Kasper[1] have recently shown that the $F_{h,k,l}$'s must satisfy certain relations of inequality, and that these relations sometimes enable one to decide unequivocally for some values of (h,k,l) whether $\alpha_{h,k,l}$ is $+1$ or -1. I have succeeded in extending these ideas and have established several large classes of inequalities between $F_{h,k,l}$'s. Applying the inequalities to the data on oxalic acid given by Robertson and Woodward[2], I have been able to determine the signs of some forty-two terms. I believe that more of the signs can be obtained directly, though I have not yet succeeded in doing so. In any event, however, these forty-two terms give a more than adequate first approximation, which can be followed up either by the usual methods or by the use of modern computing machinery.

Apart from the practical application of these ideas to the determination of phases, they also lead to some rather curious restrictions on the structure-factors. I have investigated a number of cases and have verified that these restrictions were, in fact, always satisfied, though no really adequate physical explanation of them suggests itself.

A full account of the whole subject will shortly be published elsewhere.

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Meson Decay and the Theory of Nuclear Forces

IN recent observations with the photographic plate method, Lattes, Muirhead, Occhialini and Powell[1] have given direct evidence of cosmic ray mesons with two different masses; furthermore, in some of their pictures the heavier meson stops in the emulsion and emits a lighter meson. At first one is tempted to identify these two mesons with the vector and pseudoscalar ones postulated in the Schwinger mixed meson theory of nuclear forces. Wentzel[2] has, in fact, recently suggested that a vector meson can disintegrate into a pseudoscalar meson plus a photon, and one might conjecture whether this is not the process observed by the Bristol group[1]. According to calculations by Finkelstein[3], this process has a lifetime of 4×10^{-18} sec. and would thus be too fast to

be detected in the plate. Finkelstein's results show, in addition, that the contribution of the vector meson instability to the soft component of cosmic radiation would result from that process, that is, from photons and not from β-decay, which would then be slower by a factor of 10^{10}.

More recent data[4] indicate, however, that the meson decay of mesons is probably accompanied by the ejection of light neutral mesons instead of photons. If this is true, Schwinger's usual mixed theory cannot account for the meson decay. Apart from the difficulty that Finkelstein's theory gives too short a life-time for this process, one would have to assume in this theory, besides the usual vector and pseudoscalar mesons, lighter mesons with spin 1. The scheme of the process would then be

$$\mu_{\nu}^{\pm} \rightarrow \mu_{\mu\nu}^{\pm} + \mu'_0, \qquad (1)$$

where μ'_0 is a spin 1 neutretto with a mass of the order $\frac{1}{7}$ of that of $\mu_{\nu}^{\pm}$ [4]. The additional assumption of a light vector neutretto field to account for this scheme would destroy the regularity of the non-relativistic potential of two nucleons in Schwinger's theory, unless a corresponding light pseudoscalar neutretto field were also introduced. One possibility which is open is given by a non-symmetrical mixture of two meson fields. Hulthén has already suggested a mixture of a neutral scalar and a charged pseudoscalar field[5]. But one might assume that for a given field the meson mass and the coupling constants depend on the charge. In this case, the potential energy of two nucleons as derived from a vector field would be

$$V = \sum_a \tau_a^{\mathrm{I}} \tau_a^{\mathrm{II}} \left\{ (g_1^a)^2 + \tfrac{2}{3} (g_2^a)^2 (\vec{\sigma}_{\mathrm{I}} \cdot \vec{\sigma}_{\mathrm{II}}) - \tfrac{1}{3} (g_2^a)^2 S \left(\frac{3}{(\mu_a r)^2} + \frac{3}{\mu_a r} + 1 \right) \right\} \frac{\exp(-\mu_a r)}{r};$$

S = tensor force;

and analogously for the potential as deduced from the pseudoscalar field. One can then have immediately the potential by mixing the two fields.

We have, in particular, examined the non-symmetrical Møller–Rosenfeld mixture[6]. In this case, and assuming that the coupling constants are the same for charged and neutral mesons, the theory will give a neutron-proton interaction in the ^1S state slightly larger than the (specifically nuclear) proton-proton interaction in the same state if the neutral meson mass is slightly larger than the mass of charged mesons. Such a result might be consistent with Hanstein's observations[7]. In Born's approximation, the effect of varying the neutral meson mass on the anisotropy of neutron-proton scattering at 14 MeV. gives no substantial deviation from the prediction of the symmetrical theory. However, one would need a neutral meson lighter than the charged ones for process (1), and this would make the proton-proton potential in the singlet state larger than the neutron-proton potential in the same state, which is at variance with the available experimental evidence. The same conclusions are expected to result in the case of a non-symmetrical Schwinger's mixture.

Another possibility would be to assume light pseudovector mesons in addition to pseudoscalar and vector mesons. But there still remains the difficulty of too short a life-time for the meson decay with emission of photons, if one wishes to identify the heavier meson of the Bristol group with a spin 1 meson. If, therefore, the meson decay of mesons is accompanied by the emission of light neutrettos, a more radical change will be needed in the present meson field theory of nuclear forces.

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Interpretation of Radio Echoes from Polar Auroras

In a recent communication, Lovell, Clegg and Ellyett[1] describe radio echoes from polar auroras. A remarkable feature was a persistent echo on 6·5 metres wave-length (46 Mc./s.) with an amplitude three times the noise-level and a distance of 480 km. The echo was not observed on 4 metres wave-length; it finally disappeared when striations occurred in the aurora.

The observers have kindly supplied the following data on the radar set used for the observations: peak transmitter power 50 kW. on 6·5 m., 100 kW. on 4 m.; aerial gain of 4 compared with a free dipole for transmitter and receiver on both wave-lengths; noise-level equivalent to $1{\cdot}8 \times 10^{-14}$ watts receiver input on 6·5 m., and to $0{\cdot}4 \times 10^{-14}$ watts on 4 m.

If the echo was due to reflexion from a plane surface, the reflexion coefficient, that is, the ratio between incident and reflected energy, would be of the order 5×10^{-7}. The well-defined range of the echo indicates that reflexion from a plane surface is a plausible assumption, and even if the plane reflector is replaced by an irregular surface, the magnitude of the reflexion coefficient would not be substantially altered, since the aurora covered an appreciable area of the sky.

Radar observations of meteors during this auroral display indicated no increase in the absorption up to 90 km. height, and the electron collision frequency at greater heights is too small to be effective at radio frequencies of 46 Mc./s. or more. The very low reflexion coefficient is therefore not due to absorption, but indicates that the auroras were practically transparent to radio waves of 46 Mc./s. frequency. *The electron density must therefore be considerably smaller than* $2{\cdot}6 \times 10^7$ *electrons per c.c.*

In a transparent layer of uniform electron density, the reflexion coefficient depends on the electron density and on the sharpness of the boundary layers. For a given maximum electron density, the reflexion coefficient is highest when both boundaries are perfectly sharp, and the radiation from both boundaries is received with the same phase. If these conditions are fulfilled, the optimum reflexion coefficient is

$$R = \frac{e^4}{4\pi^2 m^2 \nu^4} N_0^2. \qquad (1)$$

Equation (1), which is valid for small R, shows that if $R = 5 \times 10^{-7}$, *the electron density* N_e *must be greater than* 4×10^4 *electrons per c.c.*

If the boundaries are diffuse, the optimum reflexion coefficient R is reduced by a factor

$$f = \left| \frac{1}{N_e} \int \frac{dN}{dx} \exp\left(i \frac{4\pi}{\lambda} x\right) dx \right|^2. \quad (2)$$

It is assumed in (2) that R is considerably less than unity. λ is the radio wave-length *in vacuo*; the integration is extended over the boundary layer.

If N_e is near the lower limit, f must be nearly unity; if N_e is approaching the upper limit, f must be of the order 10^{-6}. From these limiting values of f we can obtain information on the sharpness of the boundary layers. Assume, for analytical simplicity, that

$$\frac{dN}{dx} = \frac{N_e}{a\sqrt{\pi}} \exp\left(-\frac{x^2}{a^2}\right), \quad (3)$$

which would correspond to a sharp boundary which has been subject to a diffusion process. We find in this case

$$f = \exp\left(-\frac{8\pi^2 a^2}{\lambda^2}\right), \quad (4)$$

and using the lowest permissible value of f, we find that $a < 3$ metres.

It is known from aurora photographs[2] that the sides of draperies and rays appear sharp to within less than a few hundred metres; the limit is set by the resolving power of the cameras and films. From the present interpretation of radio echoes, it appears that the boundaries are sharp within some metres. This conclusion depends to some extent on the analytical expression which is chosen to represent the electron distribution in the boundary layers, but different expressions give the same order of magnitude.

Diffusion in the aurora-levels is too fast for the boundaries of an accumulation of electrons to remain so sharp for 20 min. Aurora photographs show that the lower borders of arcs, draperies and rays are much less clean-cut than their vertical sides. For these reasons it is difficult to understand how the radio echo described by Lovell, Clegg and Ellyett could be caused by reflexion from the bright area which was observed near zenith. As an alternative interpretation it may be suggested that the echo was due to reflexion from the vertical surfaces of a stationary discharge (an auroral arc) at a range of 480 km. close to the northern horizon, and that the reflexion occurred from the point where the radius from the radar station was normal to the surface of the arc. Since such arcs follow the lines of magnetic field, this point would be located at about 200 km. height over the north of Scotland; aurora records from this region during the night of August 15–16 would be very desirable. It is worth noting that a height of 200 km. is well above the region of maximum luminosity in ordinary auroral arcs.

As seen from equations (1) and (2), the reflexion coefficient should decrease with decreasing wave-length, and it may be readily understood that the echo was observed on 6·5 metres, but not on 4 metres wave-length. The disappearance of the echo when the aurora split into rays is also to be expected, since a plane arc is a more efficient reflector than a cylindrical ray.

Further observations of this kind during magnetic storms and auroras would be desirable. If the echoes detected by Lovell, Clegg and Ellyett are due to reflexions from a point well above the luminous parts of an auroral arc, there is a possibility that echoes might be observed from the current sheets outside the earth's atmosphere during magnetic storms. For this purpose one might, as a first guide, assume that the auroral discharges take place on the surface generated by the magnetic field lines through the aurora zone, and for each locality the most favourable directions and ranges can be readily evaluated from the condition that the radius from the station should coincide with the normal to this surface.

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Low-Temperature Polymerization of Isobutene by Titanium Chloride

It has been shown in previous communications[1,2] that the low-temperature polymerization of isobutene in hexane solution by titanium chloride ($TiCl_4$) requires a co-catalyst. Water was found to be an effective co-catalyst, but only when introduced into the reaction mixture in the form of vapour, where it presumably forms crystallites of high specific surface which react with the titanium chloride. These considerations, and the milky appearance of the polymer solution at the end of the reaction, indicated that the initiation step at least might be heterogeneous.

Using the apparatus and method previously described[2], it was found that the reaction could also be initiated by the addition of a few drops of commercial concentrated sulphuric acid. 20 per cent oleum had the same effect, so that it is improbable that the active principle in the sulphuric acid was the water contained therein. Neither sulphuric acid nor oleum alone (without titanium chloride) initiate polymerization at −70° to −80° C., although they do so at room temperature. The reaction initiated at about −80° C. by concentrated sulphuric acid or oleum as co-catalyst is of an extreme violence comparable with that of the boron trifluoride catalysed reaction.

Concentrated sulphuric acid, oleum and water were not considered altogether suitable co-catalysts for kinetic studies, and a co-catalyst was sought which would be soluble and which would form a titanium chloride complex also soluble in hexane. The substances acting as co-catalysts in the boron trifluoride catalysed, room-temperature, gas-phase polymerization of isobutene, such as acetic acid[3,4,5], which are soluble in hexane, were found to act as inhibitors to the titanium chloride catalysed, low-temperature, liquid-phase polymerization of isobutene. Further search was made for a hexane-soluble acid of strength comparable to sulphuric acid. It was found that dry trichloracetic acid in hexane solution was an efficient co-catalyst. The titanium chloride – trichloracetic acid complex was found to be soluble in hexane at the concentrations used at temperatures so low as −85° C. Polymer solutions produced by titanium chloride – trichloracetic acid are free from opacity or even

opalescence until exposed to the atmosphere. With a ratio of chloride to acid less than about 4, the curves showing the progress of reaction with time are slightly sigmoid, but for higher values of this ratio their slopes decrease monotonically from the start. For starting temperatures near −80° C., the maximum rate of the polymerization under adiabatic conditions is found to be a function of the concentrations of isobutene, titanium chloride and trichloracetic acid, and of the initial temperature. The detailed relationships are being investigated.

Picric acid, the dissociation constant of which is of the same order as that of trichloracetic acid, was found to be inactive as co-catalyst, but did not affect the polymerization afterwards induced in the same reaction mixture by the addition of trichloracetic acid. Monochloracetic and dichloracetic acids were found to possess practically no co-catalytic activity at −75° C., but slowed down considerably the polymerization afterwards induced by the addition of trichloracetic acid.

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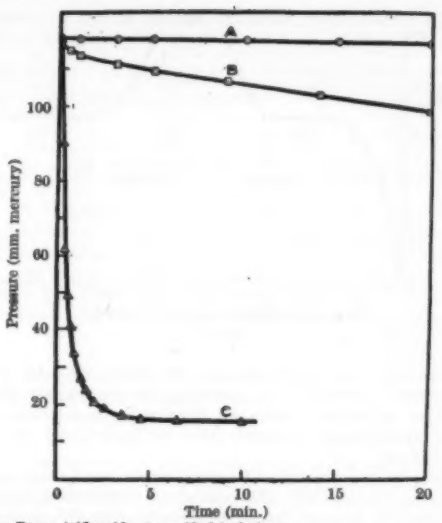
Polymerization of Olefins by Friedel-Crafts Catalysts

Earlier work has shown that pure isobutene gas and pure di-isobutene vapour do not undergo reaction when mixed with gaseous boron trifluoride[1]. In the presence of a trace of some third component, or co-catalyst as we shall call it, these monomers undergo very rapid polymerization when mixed with boron trifluoride. Water[1] and *t*-butyl alcohol[2] act as co-catalysts in this way.

We now find that acetic acid also is an effective co-catalyst in these reactions. Isobutene gas containing as little as 0·06 per cent acetic acid vapour polymerizes very rapidly when boron trifluoride is mixed with it (Curve *C*). The introduction of boron trifluoride into this isobutene – acetic acid mixture is accompanied by a dense fog and by the formation of liquid polymer throughout the whole system. The slow reaction which occurs when purified isobutene gas is mixed with boron-trifluoride is shown for comparison (Curve *A*).

The action of the co-catalyst has been attributed to the fact that it forms an addition complex with the boron trifluoride, which complex then loses a proton to the olefin, thus forming a carbonium ion which can initiate a polymerization chain[3].

We have prepared a crystalline boron trifluoride acetic acid complex by mixing acetic acid vapour with excess boron trifluoride gas*. The introduction of purified isobutene gas into a system containing crystals of this complex resulted in the rapid polymerization of the isobutene. This polymerization took place entirely on the surface of the complex. Since the complex covered only a very small portion of the reaction vessel surface, the major part of this surface was completely free from liquid polymer.



A: Boron trifluoride + purified isobutene
B: " " " " + 0·01 mm. acetic acid
C: " " " " + 0·06 " " "

This experiment shows that in this case the polymerization of isobutene is a heterogeneous process occurring on the surface of particles of complex.

Further evidence for this conclusion was obtained by the following method. Isobutene gas, containing sufficient water as co-catalyst to give a slow reaction, was mixed with boron trifluoride in a reaction vessel (vessel 1). After 1–2 hours, this reaction mixture was expanded into a second reaction vessel (vessel 2), and the connexion between these vessels was then closed. It was found that the polymerization continued in vessel 1, but that there was no reaction in vessel 2.

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* A crystalline complex between boron trifluoride and acetic acid has been isolated by Meerwein and Pannwitz, *J. pr. Chem.*, **141**, 123 (1934).

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Use of a Palladium Tube Technique in the Study of the Role of Hydrogen in Combustion Systems

From the experiments of H. B. Dixon[1] and later workers, the importance of the presence of hydrogen-containing species in the combustion of carbon monoxide is generally recognized. The wet oxidation is a chain reaction in which these bodies provide the chain carriers. Recent experiments[2,3] which prove the dominant role of the wet carbon monoxide–oxygen reaction during the high-temperature oxidation of carbon leads to a similar conclusion, namely, that small amounts of hydrogen or its compounds are necessary for the production of fully burnt gases during the combustion of solid fuels.

We have found that the stationary hydrogen concentration obtaining during the combustion of carbon

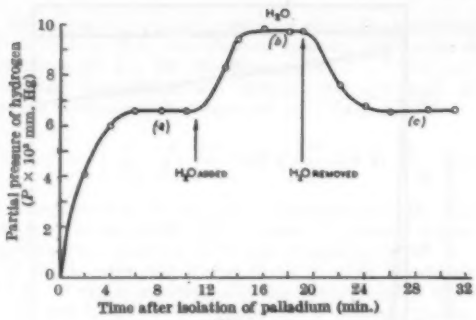

Fig. 1

monoxide – air mixtures at a jet flame may be conveniently followed by inserting an evacuated thin-walled palladium tube in the flame and observing the equilibrium pressure (due to hydrogen) set up within it[4].

In our experiments the gases were dried over magnesium perchlorate, and contained sufficient moisture to give a steady flame even when small amounts of inhibitors were present in the air. The balance of heat transferred from the flame to the palladium tube and heat lost by conduction and radiation was such as to maintain the tube at a temperature near 700° C.

We found that: (i) an equilibrium pressure was reached in 6–8 min. (Fig. 1 at *a*); (ii) the pressure within the tube responded rapidly when moisture was added to the gases fed to the flame (Fig. 1 at *b*); (iii) the diffusion process was quantitatively reversible and hence quite specific for hydrogen at the above temperatures. Fig. 1 shows at *c* that the pressure set up in the palladium tube due to addition of water vapour to the gases falls to its initial value when the water is cut off.

The equilibrium state is presumably a property of the flame alone. The approach to that state is a property of the flame, the tube, and the volume of the evacuated space. Since the reaction $H_2 \rightleftharpoons 2H$ occurs at the palladium surface, it is presumed that the measured pressure is due to the average total hydrogen concentration of the flame in contact with the palladium.

The effects of inhibitors of the combustion on the hydrogen pressure may be conveniently followed. Fig. 2 shows the influence of a minute quantity of phosphorus trichloride on the measured pressure; hydrogen chloride gives a similar result. A correlation is possible between the hydrogen content of the

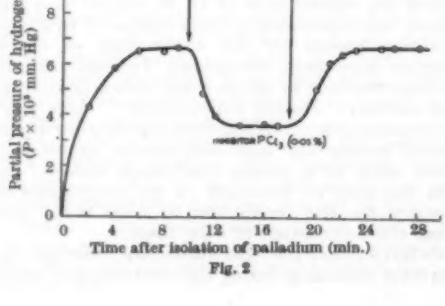

Fig. 2

flame and its stability (that is, the flame speed) in the presence of the added compounds. In this connexion, it is interesting to observe that Tanford and Pease[5] have recently made estimates of the hydroxyl and atomic hydrogen and oxygen concentrations in carbon monoxide flames. They find a striking correlation between burning velocity and atomic hydrogen concentration, but little correlation with hydroxyl and atomic oxygen concentrations.

It is found quite generally that those compounds which markedly increase the ratio of carbon monoxide to dioxide in the combustion of carbon[6] at 750–850° C. drastically reduce the hydrogen content of a carbon monoxide flame.

The technique is being used to investigate the effect of fine powders on combustion processes in gaseous and solid fuel systems, as part of a programme relating to the control of reactions in fuel beds. The results will be reported fully elsewhere.

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Nature of the Hydrogen Bond in Potassium Hydrogen Fluoride

In 1941 Ketelaar[1] published accurate measurements on the infra-red absorption and reflexion spectra of potassium hydrogen fluoride (KHF_2). The two strong peaks of 1450 and 1222 cm.$^{-1}$ were interpreted as a doubling of the fundamental asymmetric valence frequency ν_3 belonging to the vibration of a proton between two F^- ions. The doubling was assumed to be caused by a double-minimum potential curve of the type occurring in the NH_3 molecule. The splitting of the lowest vibrational level was estimated to be 25 cm.$^{-1}$ and the distance between the two equilibrium positions 0·70 A.

On the basis of this interpretation of the spectrum one would expect, however, that the ratio of the distances between the two absorption peaks for KDF_2 and KHF_2 should be very much smaller than the value (about $2^{-1/2}$) which was found experimentally. This can be deduced from the formulæ of Dennison and Uhlenbeck[2], and is due to the fact that in KDF_2 the mass of the resonating particle is twice as large as in KHF_2. It can scarcely be expected that the change in the potential curve accompanying the substitution of H by D would compensate this effect almost exactly. Therefore, we believe that Ketelaar's interpretation of the spectra is not conclusive.

There is another criterion which may be used in order to test Ketelaar's assumption. This assumption leads to the conclusion that the dielectric permittivity of KHF_2 should be strongly dependent on temperature. This is a direct consequence of Van Vleck's principle of spectroscopic stability[3], which predicts a term proportional to T^{-1} contributing to the

permittivity at temperatures large in comparison with the double minimum splitting of the lowest level; that is, the dielectric behaviour at these temperatures should be exactly as if free permanent electric dipoles were present in the crystal.

In order to test this point, Dr. Gevers and Mr. Camfferman of this Laboratory carried out some dielectric measurements on potassium hydrogen fluoride in 1945. They found that the temperature coefficient $\varepsilon^{-1}\, d\varepsilon/dT$ of the dielectric permittivity was about $+ 2 \times 10^{-4}$ in the temperature region between 80° and 300° K., while the loss angle was smaller than 10^{-3}. From Ketelaar's data one would expect a negative temperature coefficient of an order of magnitude varying from $- 10^{-2}$ to $- 10^{-3}$ in this temperature region.

We are thus in agreement with the conclusions of Pitzer and Westrum[4], who based their arguments on the absence of a heat-capacity peak in the low-temperature region.

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Reaction of Hydrogen Atoms with Solid Carbon

Avramenko[1] has recently announced the discovery of evidence for the direct reaction of atomic hydrogen with soot at a temperature of 100° C. We wish to report additional confirmation of the occurrence of this reaction in independent work which has been proceeding in our laboratory for several months.

Hydrogen atoms, produced by the standard Wood–Bonhoeffer technique[2], were pumped into a cylindrical reaction chamber of approximately 7 cm. diameter and 35 cm. length, the walls of which were internally 'poisoned' against excessive hydrogen-atom recombination by means of a coating of phosphoric acid. At an operating pressure of 0·4 mm., a 20 per cent atom concentration was readily maintained in the reactor, into the centre of which could be introduced a water-cooled glass finger thinly covered with solid reactant. Provision was made for collecting volatile products other than hydrogen by including in the exhaust system a silica gel-filled trap maintained at liquid air temperature. This method has been successfully utilized in work of this nature by several previous experimenters[3], and blank runs with hydrogen–methane mixtures in our present apparatus confirmed the suitability of the procedure. Possible higher hydrocarbons would, of course, be retained even more strongly than methane.

Runs of 45 minutes duration were carried out, in which soot deposits (made by 'smoking' the glass finger with a gas flame) were treated with hydrogen atoms. Light deposits were observed to disappear completely within a few minutes, although heavier coatings were cleaned off only partially during the reaction period. In some of the runs with heavy carbon deposits, the gaseous product exclusive of hydrogen was collected in the manner already described, and separated in part by distillation at − 185° and at − 100° C. Typical results, given in terms of c.c. of gaseous product measured at N.T.P. were as follows:

c.c. product volatile at − 185° C. (i.e., CH_4)	c.c. product volatile at − 100° C. (i.e., C_2 to C_5 fraction)	c.c. product involatile at − 100° C.	Temp. of cooling water in glass finger
6·0	0·5	nil	(uncooled)*
6·3	0·9	nil	45° C.

* No cooling water passed in this run. Temperature of sooted finger probably high, due to heat of hydrogen-atom recombination.

The experiments thus far have been of a purely exploratory nature, and a more comprehensive investigation is now in progress. The mechanism of the reaction poses an interesting kinetic problem, particularly with respect to the identity of such free organic radicals as may appear in the gas phase.

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Sept. 3.

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Effect of Injection of Adrenaline on the Anaerobic Glycolysis of Rat Diaphragm

Part of the action of adrenaline in raising the blood sugar has been attributed by Cori *et al.*[1] to a decrease in utilization of glucose by the tissues. Other workers arrived at different conclusions.

For the following experiments, the anaerobic glycolysis of rat diaphragm was determined 40–60 min. after subcutaneous injection of 1 mgm. adrenaline/kgm., on the assumption that the rate of glycolysis would reflect glucose consumption in the skeletal muscle throughout the body. The Q_{CO_2} for diaphragm of adrenaline-injected animals was found to be 29 per cent inhibited as compared with controls (see table).

Rats	Average Q_{CO_2}		Inhibition (per cent)
	Untreated controls	Adrenaline treated	
Normal* (36 expts.)	2·44	1·74	29
Adrenalectomised (12 expts.)	3·38	2·30	31
Hypophysectomised (26 expts.)	2·38	2·32	0

* For every experiment two rats were used.

The failure to obtain any inhibition of glycolysis by addition of adrenaline to diaphragm or muscle extracts *in vitro* suggested an indirect action. Such an indirect action could consist in a stimulation by adrenaline of the hypophysis or the adrenal cortex, causing a release of the corresponding hormones leading to the suppression of carbohydrate utilization. A possible mechanism for this action could be the hexokinase-inhibiting effect of the hypophysis described by Colowick *et al.*[2], which effect is increased by adrenal cortical hormone and reversed by insulin.

Addition of diabetogenic hypophysis extract kindly made available by Prof. F. G. Young did not affect diaphragm glycolysis. Adrenal cortical hormone (eschatin), however, gave in nearly all cases an inhibition of 30–50 per cent. Insulin addition caused an increase in glycolysis. Since the intrinsic pituitary

hormone content of the diaphragm may be optimal and since added hypophysis extract may not penetrate, these results are not in disagreement with Colowick's theory.

Next the effect of adrenaline injection was studied on the diaphragm glycolysis of hypophysectomized and of adrenalectomized animals (see table).

Adrenalectomized animals show a normal response to adrenaline injection, indicating that indirect stimulation of the adrenal cortex by adrenaline as described by M. Vogt[3] plays no part in the effect. Hypophysectomy, however, abolishes the adrenaline effect. The part played by the hypophysis could be a release of a hexokinase-inhibiting hormone under the influence of injected adrenaline, but other mechanisms, in particular pituitary influence on the action of adrenaline itself, or an active derivative, remains possible. Investigations to elucidate these possibilities are in progress, and a detailed report will be published later.

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Sept. 5.

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Influence of Adenohypophysectomy on the Transfer of Salt Across the Frog Skin

It is well known that the isolated skin of the frog is able to transport salt from its outside to the inside when bathed with frog Ringer on both sides[1]. In view of the fact that cortical hormones play an important part in the reabsorption of sodium chloride in the kidney, an investigation was made to learn whether the skin of hypophysectomized frogs, in which cortical secretion presumably is considerably decreased, is still able actively to transport salt. In specimens of *Rana temporaria* the adenohypophysis was removed, and the animals, together with unoperated controls, were kept without food in water at 10°–15° C. Three operated animals, two males and one female, of healthy appearance, were used in the experiments. The operations were carried out in November. The secretion of the skin of the operated frogs was very markedly reduced. This effect of hypophysectomy on the toad has already been described by Aubrun[2].

In May—about six months after the operation—the skin was tested (1) for ability to transport salt, and (2) for permeability to salt. Pouches made from the skin of the thigh (cf. Huf) were filled with 1·5–2 ml. frog Ringer or water and placed in small vessels containing 10 ml. aerated frog Ringer. The *p*H was kept at about 7·4, the temperature at 22° C. The passage of salt through the skin was followed either by chloride titration (when Ringer was used inside the pouch), or by conductivity measurements on the content of the pouches (when starting with water inside the pouches) using a Philip's Philoscop, A.C. 1,000 cycles[3].

Table 1 shows the result of the experiments when Ringer was applied on both sides of the skin. As was

Table 1

	Hypophysectomized	Normal
μ mol. Cl/hr./cm.²	0·27, 0·37	0·24
	0·49	0·38
	0·56	0·54

Table 2

	Hypophysectomized	Normal
μ mol. Cl/hr./cm.²	0·73	0·05
	0·74	0·10
	0·82	0·13

to be expected, the transfer of salt occurred from the physiological outside to the physiological inside of the skin. The results are expressed in μ mol. Cl per hour per cm.² of the skin. It is seen that with regard to the ability of transporting salt, no demonstrable difference exists between the skin of normal and of operated animals. Starting with water inside the skin pouch, the results given in Table 2 were obtained. The figures represent the rate at which salt was lost into the pouch. The skin of operated frogs is found to be several times more permeable than normal skin. It is therefore not surprising that the adenohypophysectomized frogs were unable to keep the chloride ion concentration of the blood at a normal level. Table 3 shows the chloride concentration in the lymph two and five months after the operation. The chloride determinations were performed on 3 mm.³ samples of lymph taken from the lymph-sac by means of a Carlsberg constriction pipette through a small incision in the skin.

Table 3

	Hypophysectomized		Normal	
	Months after operation			
	2	5	2	5
mmol./l. Cl of lymph	58	47	69	84
	64	55	75	75
	—	48	70	81

It may be concluded that the salt transport of the skin of the frog may function even in the absence of the adenohypophysis. However, directly or indirectly, perhaps via cortical action, this gland is necessary for the maintenance of the very low salt permeability characteristic of the normal skin.

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Sept. 8.

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Critical Moisture Content of Dehydrated Stockfish

Investigations conducted in this Laboratory into the dehydration of stockfish (*Merluccius capensis*) have indicated that the moisture content of the dried product has a great influence on its keeping quality.

Whereas such products as dehydrated vegetables, dried fruit, dried whole milk and dried eggs have their storage life lengthened with reduction of the moisture content of the dried product, the reverse relationship has been found to hold for dehydrated stockfish.

Below 8 per cent moisture content, there is a sharp reduction in the storage life of dehydrated stockfish with every decrement in moisture content. The deterioration takes the form of both discoloration and loss of flavour. The re-incorporation of the liquid extracted from the flesh during the preliminary cooking of the flesh by steam also retards the rate of deterioration, but not sufficiently to give an effective storage life. With increasing moisture content above 8 per cent there is still evident a small improvement in quality of the dried product

up to the moisture limit where spoilage by micro-organisms intervenes. The improvement per increment of moisture content is small above 16 per cent moisture content.

The storage life of the dehydrated product packed in an inert atmosphere with moisture content less than 5 per cent is approximately six weeks, and with a moisture content of 16 per cent it is up to twelve months.

The reversal of the relationship that exists between moisture and deterioration in other dehydrated products is of considerable interest in view of the fact that many laboratories are searching for clues as to the nature of the deterioration that takes place in dehydrated products.

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Aug. 14.

Cobalt Deficiency in Sligo

ON a farm on sandy soil in Co. Sligo where sheep pine and die, and cattle show pronounced ill-health, the administration of cobalt to the stock restores health and increases productivity to a remarkable degree. The herbage is definitely deficient in cobalt. The stock on this particular farm are confined to it, while the stock from neighbouring farms in which the pronounced cobalt deficiency symptoms do not appear have alternative pastures.

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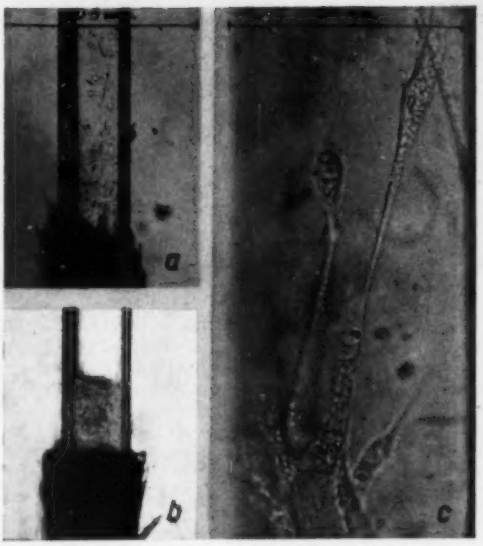
A Method for Observing Growing Epithelial Tissue in *Rhodnius prolixus* (Hemiptera)

ALTHOUGH it has been accomplished in the case of the hæmatocytes and imaginal disks of *Drosophila*[1], the cultivation of insect tissue *in vitro* has proved to be very difficult. A method by which growing epithelial tissue can be observed in transmitted light, while still in connexion with the hæmolymph and the epithelium of the living insect, may therefore be of general interest. The method is based on the fact that epithelial cells, after injury, will grow along any surface, and that if a wound is covered with glass, the cells will spread rapidly on the surface of the glass[2].

A hind leg of a freshly fed fifth-stage nymph of *Rhodnius* is amputated in the distal part of the tibia. A fine glass tube about 2 mm. long and 0·15 mm. thick is then introduced into the opening of the tibia, so that it is covered for about 0·2 mm. of its length by the cuticle. This operation is made while the leg is immersed in Ringer solution. The Ringer solution is then withdrawn and the distal end of the capillary tube sealed with paraffin wax. For the observation the insect is fixed on a special slide. The treated leg is immersed in water and covered with a cover-slip. For observing with the oil-immersion objective, the leg is imbedded in paraffin wax of low melting point up to the amputation level and the glass tube immersed in golden syrup. By this means excellent optical definition of the cells growing on the upper surface of the tube can be secured. At a temperature



PHOTOMICROGRAPHS OF CULTURES OF LIVING EPITHELIAL TISSUE IN *Rhodnius prolixus*. (*a*) EARLY STAGE (TWO DAYS) WITH HÆMATOCYTES AND FEW EPITHELIAL CELLS. (*b*) LATE STAGE (NINE DAYS) WITH CONTINUOUS EPITHELIUM. (*c*) SOME EPITHELIAL CELLS FOUR DAYS AFTER THE OPERATION

of 25° C. this preparation can be kept under quite normal physiological conditions for about twenty-five days, that is, until the insect moults. It is very sensitive to heat and to strong illumination.

In a fresh preparation a great number of hæmatocytes can be observed. They are spherical or elongated while floating freely in the hæmolymph, but become more elongated and flattened when they attach themselves to the walls of the glass tube. Many cell divisions can be observed in hæmatocytes in the first days, but after five to six days they become vacuolated and degenerate very quickly, leaving behind little droplets.

After the first 12–14 hours the first epithelial cells migrate into the visible part of the tube. They are closely applied to the wall of the tube and move by extending and withdrawing pseudopodia. They are always connected with each other and with the epithelium of the leg by long, highly birefringent protoplasmic threads. The cells move at a speed of 30–40 μ per hour, so that after another twenty-four hours they may cover almost 1 mm. of the tube with a sparse network of cells, interconnected by protoplasmic processes. The movements of the single cells can easily be followed and many details observed. The addition of a green filter increases the visibility of the nucleus. Although at first the cells move only along the walls, the protoplasmic threads connecting them can loosen themselves from the wall and run right across the lumen of the tube. Other cells can then migrate along these threads, so that after a time these paths often become densely crowded. After about seven days, many cells congregate at a distance of about 0·5 mm. from the amputation-level. The empty proximal regions then gradually become filled up with cells, but the more isolated cells in the distal part of the capillary begin to degenerate. A continuous epithelium which covers about 0·3–0·5 mm. of the tube will be formed by the tenth day, and after that only cell divisions occur. The preparation

is then no longer suitable for the observation of single cells. Nevertheless, I hope that the method will be of use in investigating the laying down of the new cuticle of the regenerating leg.

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Sept. 9.

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Economic Control of the Relapsing Fever Tick in African Houses

THE control of the relapsing fever tick, *Ornithodoros moubata* Murray, which is widespread and alarmingly abundant in many townships and labour camps in East Africa, has hitherto proved uneconomic, owing to the marked resistance of the species to the common insecticides, and the consequent heavy dosage required. I have recently had occasion to carry out trials on a practical scale with a number of 'Gammexane' formulations, and the results have been so promising that it was thought opportune to bring the details of a simple method of treatment to the notice of all who are interested in the control of ticks.

It is a matter of simple experiment to demonstrate the outstanding toxicity of hexachlorocyclohexane to *O. moubata*. Individuals subjected to the lightest dusting with a commercial dust containing 0·5 per cent of 'Gammexane' begin to lose their power to co-ordinate leg movements after 4–6 hours. They may lose up to 10 per cent of their body weight in twenty-four hours by excessive coxal secretion, by defæcation of milky fluid, and probably also by increased permeability of the tough integument. There is in many cases a darkening of colour, due to the diffusion of ingested hæmoglobin compounds from the gut to the body cavity. The ticks become immobile, except for feeble but persistent, and sometimes rhythmical, leg movements, after periods varying from twelve hours to five days, according to age, and mortalities of 80–100 per cent result after 8–10 days. In the case of adult ticks, and particularly of gravid females, individuals have shown leg movements up to two months after treatment, but any eggs laid have invariably failed to hatch. The parallel action of D.D.T. 5 per cent dust is slower and less effective, although mortalities of 50–80 per cent have been secured after more than twenty days.

In the field, the most economic treatment has proved to be the 0·5 per cent 'Gammexane' dust, applied directly to the floors and the first few inches of the walls of infested houses. Application is made with a simple shaker such as a cigarette tin of the circular type, at the rate of 3–4 lb. of dust per 1,000 sq. ft. of surface. The results are checked by a standard system of survey, in which a team of five 'boys' searches the floors to a depth of 1½ in. at random for five minutes. By this means, the infestation figures in a labour transit camp have been reduced from an average of 20 per unit sample to less than 0·2 over a period of nine months. There was evidence that retreatment was required after this time, possibly owing to consistent re-infestation from transit labourers, who commonly carry the ticks in their bedding.

Since the cost of the material used, if prepared by the dilution of the commercial dust concentrate (2·5 per cent 'Gammexane') with a local diluent, of which the best appears to be a light diatomaceous earth ('Diatomite'), is in the region of 4·5*d.* per lb., this treatment should be well within economic bounds for large-scale application. These experiments have been extended to cover an entire township, consisting of approximately 1,200 houses, 50 per cent of which are infested with *Ornithodoros*, with consequent high incidence of relapsing fever. It may be some time before the effect on fever statistics can be assessed, but the relief from the ticks is already widely appreciated, and the treatment has been officially standardized in several departments in Tanganyika as an advance on any control method previously known.

I am indebted to the Director of Agricultural Production for permission to publish this note.

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Geological Age: the Extreme Antiquity of Pegmatites from Manitoba

AN inspection of the available data on geological ages determined by the lead method shows that in two areas the pegmatite ages appear to be considerably greater than those of any other Pre-Cambrian pegmatites so far determined. These two areas are located in northern Karelia and south-east Manitoba, Canada.

The geological age of pegmatites from northern Karelia is quite often held to be the greatest age so far determined. Several specimens of uraninite have been analysed[1] and the ages, which have been recalculated here with the aid of Wickman's graphs[2], are invariably nearly $1{,}800 \times 10^6$ years, which is the mean of all the determinations. Some specimens of monazite have also been analysed[1], and although the age of each specimen is about the same (average $2{,}100 \times 10^6$ years), it is somewhat higher than the uraninite age. From these data, the probable age of the pegmatites from northern Karelia is therefore about $1{,}800–2{,}100 \times 10^6$ years. Unfortunately, no isotope analyses of the lead in these specimens are known, and it has thus not been possible to compute ages according to Pb^{206}/U^{238}, Pb^{208}/Th^{232} and Pb^{207}/Pb^{206} ratios, which would provide valuable evidence in support of, or against, the above ages for the northern Karelian pegmatites.

Two specimens of uraninite and two of monazite from Manitoba pegmatites have also given high ages, which, recalculated as stated above, range from 1,700 to $2{,}000 \times 10^6$ years. Lead from one specimen of uraninite and one of monazite has been analysed on the mass spectrograph, and serious discrepancies have been found in the 'ages' of these specimens according to whether the ages are calculated by Pb^{206}/U^{238}, Pb^{208}/Th^{232} or Pb^{207}/Pb^{206} ratios. These ages, taken from Nier[3,4], are given in Table 1.

TABLE 1

No.	Mineral and source	Pb^{206}/U^{238} age	Pb^{208}/Th^{232} age	Pb^{207}/Pb^{206} age
1	Uraninite, Huron Claim, S.E. Manitoba	1570×10^6 yr.	1252×10^6 yr.	2200×10^6 yr.
2	Monazite, "	3180 "	1830 "	2570 "

Nier[4] has pointed out that the Pb^{207}/Pb^{206} ages are quite likely to be the most reliable, and the agreement between the Pb^{207}/Pb^{206} uraninite and monazite ages given above is reasonably good. Consequently, although serious discrepancies are apparent, the agreement between the Pb^{207}/Pb^{206} ages indicates quite strongly that the age of the pegmatites from south-east Manitoba is one of the greatest yet reported.

Age determinations using the strontium method support this evidence. (For age determinations calculated according to strontium – rubidium ratios, a value of $5{\cdot}8 \times 10^{10}$ years, determined by Eklund[5], has been used for the half-life period of Rb^{87}.)

First, Strassmann found approximately 2·6 per cent rubidium and 0·155 per cent strontium, more than 99·7 per cent of which was found to be radiogenic[7] in lepidolite from the Silver Leaf Mine, south-east Manitoba, whence the strontium age is calculated as $1{,}830 \times 10^6$ years. However, some strontium may have been lost during analytical manipulations, and may be as much as 10 per cent[8], in which case the strontium age would be $2{,}000 \times 10^6$ years.

Secondly, using a spectrochemical procedure described elsewhere[9], strontium ages of four different specimens of lepidolite from south-east Manitoba have been determined (Table 2).

TABLE 2

No.	Source	Strontium age
1	Falcon Island, Lake of the Woods, S.E. Manitoba	2200×10^6 yr.
2	Along the Winnipeg River, "	2300 "
3	Silver Leaf Mine, along Winnipeg River, "	2100 "
4	" " " " " " "	2350 "

(Probable experimental error in each case about ± 15 per cent.)

These ages agree satisfactorily and are also in reasonable agreement with the other ages that have been discussed. It might be argued that as no isotope data on the strontium in these specimens are available, contamination by ordinary strontium is possible. This possibility cannot be overlooked, but the evidence against it is very considerable. First, available mass spectrographic analyses (seven in all)[10,11] have shown radiogenic strontium to predominate in lepidolite. Secondly, the ages of about twenty-five specimens of lepidolite from various localities and of different ages have been determined[12], and with few exceptions no contamination is apparent. These ages include those of Pre-Cambrian pegmatites from New Mexico, Colorado, South Dakota and Ontario, all of which are of the magnitude of approximately $1{,}000 \times 10^6$ years and are only about half the Manitoba age. Thirdly, two of the above specimens are from the same pegmatite (Silver Leaf Mine) from which the specimen containing more than 99·7 per cent radiogenic strontium was taken; and fourthly, had contamination been significant, it is highly unlikely that agreement so close as that shown in Table 2 could occur.

A consideration of the ages given in Table 2, as well as of others that have been discussed, seems to establish beyond reasonable doubt that the pegmatites from south-east Manitoba are of extreme antiquity, and that with the possible exception of the north Karelian pegmatites, which may be of about the same age, they represent the most ancient portion of the earth's crust, on which it has been possible to determine the geological age. An age of $2{,}100 \times 10^6$ years is considered reasonable for these pegmatites.

The granites from south-east Manitoba with which the pegmatites are associated are intrusive into an ancient complex, referred to by Wright[13] as the Rice Lake Series, which is composed of various types of lavas, sediments—some of which contain pebbles of a still more ancient granite—and metamorphosed equivalents. The history of the Series appears to have been quite extended. Consequently, some support is given to Holmes'[14] estimate of $3{,}350 \times 10^6$ years as the age of the earth, rather than an age of $2{,}000 \times 10^6$ years which is sometimes considered to be the most probable age.

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Aug. 26.

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Text-book Organic Chemistry

No author or editor, unless claiming omniscience, completes a text-book on organic chemistry without feeling that sprinkled through his text are erroneous, inaccurate or ambiguous statements. To confirm his forebodings comes the letter from Prof. C. K. Ingold[1] and his colleagues with the above slightly unkind title, conveying the impression that text-books often contain a peculiar if not spurious brand of organic chemistry: "clauts o' cauld parritch", as Andrew Fairservice described another kind of doubtful doctrine. But surely the tone of the letter is in places exaggerated. Neither error quoted constitutes a "howler" or solecism; and far from being "inexcusable" it is easy to understand that, despite all vigilance, erroneous statements should sometimes be made or repeated, especially should they enjoy the sanction of authoritative reference books such as Heilbron's "Dictionary".

Nevertheless, Prof. Ingold's letter is salutary and is to be welcomed both for raising an important problem and for contributing towards its solution. It is to be hoped that students, teachers and research workers will assist authors to overcome sins of omission and commission, either by private letter or by communication to appropriate journals. In the latter case, may the plea be made for publication in a prominent and accessible form. Prof. Ingold's letter complies with this requirement: his previous communication[2] on the same subject, consisting of a few lines in the middle of a longish, partly polemical paper, does not.

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ARCTIC AEROBIOLOGY

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So far as we are aware, the only published observations on the presence of micro-organisms or spores in the atmosphere overlying arctic regions are those of Meier[1,2], who investigated petrolatum-coated slides exposed by Colonel Charles A. Lindbergh during his flights over southern and central Greenland, etc., in the summer of 1933. Meier's preliminary account[1] indicated that a considerable diversity of biota was represented on Lindbergh's slides, which in most instances had been exposed for at least an hour above 2,000 ft. from an aircraft travelling at an airspeed of 110 m.p.h. Unfortunately Meier lost his life in a flying accident before the promised detailed account of this interesting material could be written. He did, however, remark[1] that in spite of the nutritionless surface "Some of the spores of fungi caught at different points show definite evidence of having been alive when trapped. . . . The potentialities of world-wide distribution of spores of fungi and other organisms caught up and carried abroad by transcontinental winds may be of tremendous economic consequence."

It was also in 1933 that one of us (N. P.) exposed nutrient Petri plates on mountain tops in northern Lapland under winter conditions, and later in Spitsbergen during the summer. But with the protracted travels and rough treatment which the plates had undergone, and the crudity of the only methods of incubation available in the field, it was felt that the unexpected number of fungal and bacterial colonies observed in some cases after only brief exposure might be due to contaminations, and so no account was published. Indeed, no reliance could be placed on these 'observations', as many of the plates appeared to be far from sterile before exposure, while in others the medium had become hardened through loss of water. However, the attempts are mentioned here as they appear to represent the first (albeit abortive) ones of their kind in the arctic and already give some suggestion of relatively abundant life in its atmosphere.

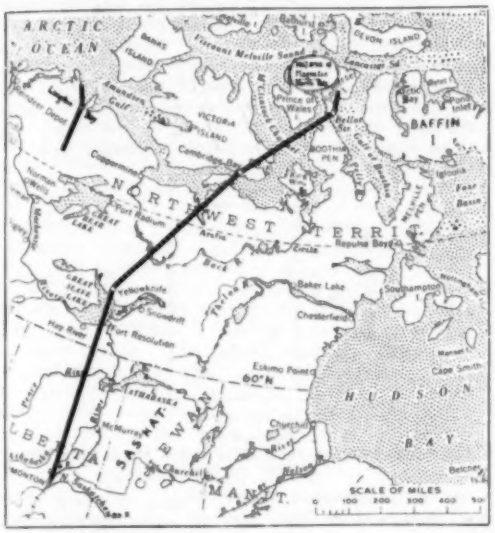
During August and September 1947, one of us (N. P.), while flying with the Royal Canadian Air Force on operations concerned primarily with geographical survey work and locating the north magnetic pole, took the opportunity of exposing from his aircraft considerable numbers of nutrient Petri plates and 'Vaselined' microscope slides especially prepared under the direction of another of us (S. M. P.). The medium employed on the plates was Czapek's solution agar with sugars omitted but with the addition of 1·0 gm. of yeast extract per 1,000 c.c., allowing only very slow growth and consequently temporary storage of the plates in the field. Two batches of nutrient plates were used in the investigation, the first being taken up with the main expedition in June, and the second being flown into the field in July. Contaminations developed in some of the plates of the first set, and these contaminated plates were consequently discarded; the second set, on the other hand, did not develop any contaminations whatsoever. Moreover, all the seven unexposed plates proved to be sterile even after they had been returned to the laboratory and incubated in mid-September. A total of fifty-one plates and fifty-two slides were exposed.

Each plate was doubly wrapped in wax and tissue papers, and was unwrapped only just before, and rewrapped immediately after, exposure, which was entirely outside the aircraft. All wrappings were secured with rubber bands, and except during exposure each cover was attached to its plate by adhesive tape, which also proved convenient for labelling purposes. An exposure was effected by thrusting the unwrapped but still covered plate in the right hand from a partially open window on the starboard side of the aircraft, holding the plate with the nutrient surface orientated vertically and hence 'flat' against the air-stream at least eight inches from the nearest point of the fuselage, then easing off the cover with the left hand and sliding it away down the right wrist and forearm, which were thus made to withstand the pressure of the air on the left hand holding the cover. The exposed plate was thus held against the full force of the airstream for precisely two minutes, after which it was covered by a reversal of the previous operation of the left hand and then brought into the aircraft to be finally labelled and wrapped. With the method evolved and precautions taken, and as was indicated by the seven controls mentioned above, there seems virtually no possibility of more than an occasional contamination.

The 'Vaselined' slides were kept in individual, specially constructed cardboard and adhesive-tape containers separately wrapped in wax paper which allowed no access of air currents until they were opened before placing the whole in a special wooden-handled, copper holder in which the sticky surface was exposed against the air-stream for five minutes in about the same position outside the aircraft as the nutrient plate: indeed, each slide and plate formed a pair, being exposed either contemporaneously or consecutively according to the type of aircraft and facilities immediately available.

Except for inevitable gaps due to liquid or ice precipitation or to preoccupation with landing, etc., a plate and a slide were exposed either every twenty or every thirty miles, approximately, throughout the flights concerned. The first of these flights was on August 12, and extended in a northerly direction from a base-camp situated on an unnamed lake north-west of Great Bear Lake to Langton Bay on the Arctic Ocean coast, and thence in a north-westerly direction to the mouth of the Horton River near Cape Bathurst, the most northerly point of the western Canadian mainland. These early exposures (numbers 1–11) were made at approximately twenty-mile intervals from the side of a 'Norseman' aircraft fitted with floats and may have been affected by bodies adhering to the fuselage or by the turbulence caused by the single propeller situated ahead of the nose, although such a possibility has been largely discounted by others[1,3]. The later exposures, comprising the vast majority in all, were made from the co-pilot's seat of a 'Canso' flying-boat of which no part lay directly ahead: the propellers stood above and well behind, and the smooth nose was situated so far below and to the side of the point of exposure that the air-stream in normal circumstances seemed entirely steady and direct. These later exposures extended over about 1,500 miles from Somerset Island southwards to Edmonton, Alberta, and were made up of three groups on flights as follows: (1) on August 26, at approximately twenty-mile intervals from Cambridge Bay, Victoria Island, in a north-

easterly direction to the south end of Somerset Island, then northwards until bad weather intervened in about latitude 73° N.; (2) on August 27, at approximately thirty-mile intervals from Cambridge Bay in a south-south-westerly direction to Yellowknife, Northwest Territories; (3) on September 5, at approximately thirty-mile intervals, from Yellowknife southwards to Edmonton. These flights, on which plates and slides were exposed, are indicated on the accompanying sketch-map.



Most of this 1947 exposing was done at or around an altitude of 5,000 ft. and airspeed 100 knots (115 m.p.h.). Details were also kept, or are being worked out, of other conditions such as wind, cloud, icing, geographical position, etc., and it is hoped through official channels to gather together sufficient extra-continental meteorological data on the 'upper air' movements of these and preceding days to get some indication of the general region of origin of the air-masses in and below which the plates and slides were exposed. Meanwhile the slides are being sent to specialists to examine for stem and leaf rust of wheat and other pathogen spores, pollen grains, etc., while we are dealing in the first instance with the considerable range of Fungi and Bacteria that are represented on the plates. Indeed, whereas we had expected few or no colonies to develop on incubation of the plates that had been exposed in the far north, for example, over the ice-fields of M'Clintock Channel, we found that almost all on return bore numerous and various colonies of Fungi and Bacteria, indicating both these groups to be abundantly and diversely represented in the arctic atmosphere. As examples we may note that plate No. 25, exposed at 4,000 ft. over the south coast of Somerset Island around latitude 72° N. and longitude 94° W., shows a total of 102 colonies of Fungi and 89 of Bacteria, while plate No. 17, exposed at 4,400 ft. over the sea-ice of M'Clintock Channel, shows 7 colonies of Fungi and 95 of Bacteria. On the other hand, plate No. 24, exposed only ten minutes earlier than No. 25 and in essentially the same region, shows only 8 fungal and 74 bacterial colonies.

Determinations and other details will take a considerable time to work out; but we would like meanwhile to report this unexpected indication of abundance of life in the arctic air and say that we hope to extend these studies in the future, and request news of any connected work.

[1] Meier, Fred C., *Sci. Monthly*, **40**, 5 (1935).
[2] Meier, Fred C., *Phytopath.*, **25**, 27 (1935).
[3] Moulton, F. R., (Ed.), "Aerobiology". (Publication of the American Association for the Advancement of Science, No. 17.) Pp. x+289. (Washington D.C., 1942.)

DIELECTRIC RESIDUAL EFFECTS IN TITANATES

By Prof. J. R. PARTINGTON, M.B.E., G. V. PLANER and I. I. BOSWELL
Queen Mary College, University of London

BARIUM TITANATE and certain related compounds having structures of the perovskite type possess exceptionally high permittivities which rise to a maximum at certain characteristic temperatures, a transition taking place from a distorted to a cubic crystal structure. The permittivity – temperature relation depends primarily on the particular material used, but is influenced also by the method of preparation, especially by the temperature at which the ceramic is fired. It has been shown that barium titanate is ferro-electric below the temperature corresponding to its permittivity maximum[1,2], and in this connexion a study of the changes with time in the permittivity and dielectric losses after a high, unidirectional electric field had been applied to materials of this type, which is now described in outline, may be of interest.

The experimental method consisted in maintaining the samples at different temperatures and determining the permittivity and dielectric losses before, and at various times after, the application of a strong D.C. field. Accurate temperature control was essential owing to the high temperature coefficient of permittivity, and a special thermostat arrangement was used, comprising a small metal chamber containing the sample, through which dried air at a constant temperature was passed. The permittivity and losses of the dried solid were determined at a frequency of 1 kc./s. and measuring tensions not exceeding 5 V./3 mm. Immediately after the application of the high tension, the electrodes of the samples were in all cases connected to earth for some seconds.

Barium titanate and a number of mixed titanates were examined, and it was found that below the temperature corresponding to the permittivity maximum, $T_{\epsilon max}$, the permittivity, shortly after the application of a high tension, had a value 3–6 per cent above that prior to treatment, and reverted at first rapidly, later more slowly, to its original value. The total time of decay varied from 10 to 50 min. from the time of cessation of the high tension.

Figs. 1 and 2 show the type of curves obtained for samples *A* and *B*, consisting of barium titanate with a permittivity peak at 112° C., and a mixed titanate with a maximum at 50° C., respectively. The effect became more pronounced at higher temperatures, being largest at a temperature just below $T_{\epsilon max}$. The time of reversion to the original permittivity was increased by prolonging the period of application of the tension. In the case of barium titanate, effects

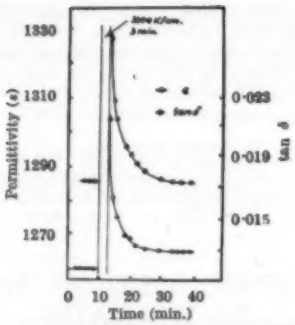


Fig. 1. SAMPLE *A*: TEMP. 24° C.; D.C. FIELD, 3300 V./CM., APPLIED FOR 3 MIN.

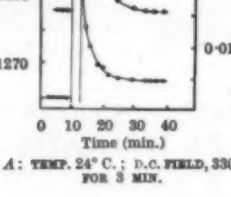


Fig. 2. SAMPLE *B*: TEMP. 24° C.; D.C. FIELD, 500 V./CM., APPLIED FOR 2½ MIN.

of the same type were observed at temperatures corresponding to the portion of the plateau in the permittivity – temperature curve in which the temperature coefficient is slightly negative (that is, between 20° and 45° C.), and in the regions where the coefficient is positive. The dielectric losses and permittivity in each case varied in a similar manner, approaching very nearly their original value after a period of 10–50 min.

At temperatures above T_{max}, the permittivity was smaller immediately after the cessation of tension and reverted slowly to its original value, the effect being largest in the case of higher tensions and prolonged periods of application. Figs. 3 and 4 show typical curves obtained for sample *C* consisting of

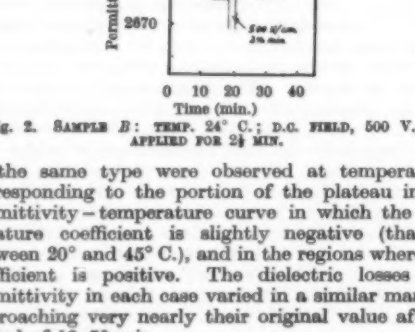


Fig. 3. SAMPLE *C*: TEMP. 70° C.; D.C. FIELD, 3300 V./CM., APPLIED FOR 1½ MIN.

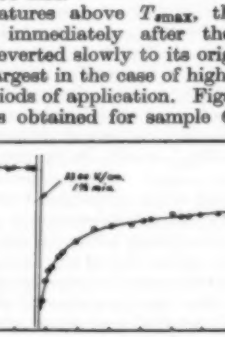


Fig. 4. SAMPLE *B*: TEMP. 80° C.; D.C. FIELD, 2500 V./CM., APPLIED FOR 3 MIN.

barium strontium titanate ($BaTiO_3 : SrTiO_3 = 75 : 25$, by weight; T_{max} : 21·5° C.), and sample *B* (T_{max} : 50° C.). Analogous results were obtained with all the compositions examined, the only exception being sample *C* at a temperature just above T_{max}, which showed a temporary increase in permittivity. The loss tangent, being low beyond T_{max}, remained constant at a value of 0·0025 and 0·001 in the case of samples *B* and *C*, respectively.

It is seen that, within the temperature range corresponding to the distorted perovskite structure, a temporary increase in permittivity was obtained, while in the region of the cubic structure a temporary decrease was generally observed. A possible explanation for the increase at a temperature just above T_{max} in the case of sample *C* may be that the two structures co-exist within a temperature range extending slightly beyond T_{max}[3,4], the effect due to the distorted structure being the larger one.

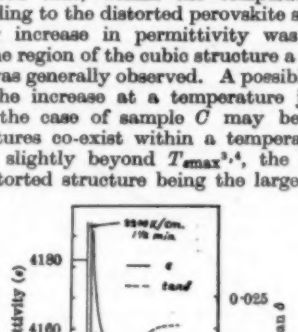


Fig. 5. SAMPLE *D*: TEMP. 30° C.; D.C. FIELD, 2200 V./CM., APPLIED FOR 1½ MIN.

At a temperature below T_{max}, a third effect was observed in the case of some compositions after the application of tensions higher than those resulting in the temporary increase in the permittivity only. Under these conditions, the permittivity approached asymptotically an apparently permanent lower value. Fig. 5 shows this effect, combined with the initial temporary increase, for sample *D* having a permittivity maximum at 50° C.

A fuller account of the work will be published later.

We are greatly indebted to the United Insulator Co., Ltd., Surbiton, for generously giving us facilities in their Research Laboratory.

[1] *J. Phys., U.S.S.R.*, **10**, 95 (1946).
[2] *Ind. Eng. Chem.*, **38**, 1097 (1946).
[3] *Trans. Farad. Soc.*, **42**, 224 (1946).
[4] *Nature*, **160**, 58 (1947).

INTERNATIONAL TIMBER CONFERENCE

A REPORT has been issued of the International Conference on Timber held at Marianski Lazne, Czechoslovakia, during April 28–May 10, 1947, under the auspices of the Food and Agricultural Organisation of the United Nations (Washington, D.C.: Food and Agriculture Organisation. 50 cents). These discussions, the first comprehensive discussions of timber and forestry to be held in Europe since the end of the War, have shown that the nations represented were in unanimous agreement on a variety of issues. The Conference did not attempt to solve all the problems of forests and timber in Europe, but con-

fined its attention to more limited objectives and admitted that, even with respect to these, its recommendations were only a starting point.

It is well known that post-war Europe is confronted with a grave timber problem. It is not a matter, as some appear to think, of merely seeking out accessible sources of supply and cutting the forests down. The large excess fellings and destruction committed during the War has led to a serious position in parts of Europe and outside Europe. Excess fellings—cutting out more than the annual increment of one or more years—means in the end the disappearance of a forest. Even to supply the well-known needs for timber of large populations we should not be justified in dooming forests which should be maintained in the interests of posterity and often for reasons quite other than timber alone.

For Europe alone it was known that more timber annually is required than pre-war Europe used; yet the soft-wood timber supplies are below the average of the year before 1939. This is delaying reconstruction. Methods of bridging the gap, it was realized, appeared to be not only inadequate but also difficult to achieve; there was also the fear that repercussions might lead to an even more serious crisis in the future; in other words, overcutting after the drain imposed on the coniferous forests during the War might lead to lasting damage to the surviving European forests. The second alternative appeared equally difficult: a reduction in timber consumption was equally undesirable, since it is in apparent conflict with improvement in housing and living standards which has been adopted as a primary objective by the United Nations Organisation. The Conference approached this matter by dividing it into three parts: (1) short-term problems; (2) long-term problems; and (3) further procedure; and the three chapters of the report deal with the problems in this manner.

The Belgian delegate reported on savings effected by substituting other materials for lumber. A memorandum was submitted by the United Kingdom on economy and the uses of timber, including restrictions and the fixing of maximum sizes in which timber is to be used for joists, rafters, floor-boards and so forth. Some of these restricted efforts, it may be said, have not proved very satisfactory, and do not help in reconstruction on the countryside.

A note had been drawn up by the Food and Agriculture Organisation Preparatory Commission on World Food Proposals, and briefly this report stated that the timber situation presents the same problem which has confronted the Commission in regard to several other commodities with, says the report, "the important difference that as food scarcities begin to subside, the world-wide timber shortage is becoming more serious".

It is suggested in the present report that a better organisation for distribution and allocation, by transport and credit facilities, would assist in some degree; the introduction of technical improvements in order to ensure better utilization of available timber supplies would also be valuable.

There is another resolution submitted by the Economic and Social Council of the United Nations, recognizing the seriousness of the present timber shortage in Europe which threatens to delay economic recovery, and this resolution welcomes the initiative taken by the Food and Agriculture Organisation. It is not possible here to deal in detail with all the resolutions and recommendations adopted by the Conference; but briefly they refer to various details in forest management and to the necessity for dealing with the world-wide shortage of timber in such a manner that serious depredations will not be made on the forests, which would result in their destruction. It is also recommended that proper organisation and proper technical methods should be introduced into the management of forests, and having regard to the long period required for the development of forest resources and for the fulfilment of domestic rational forest policies, it is considered desirable "that the European countries concerned should meet together from time to time to exchange information and views about their problems in the field of medium- and long-term forestry. F.A.O. under its existing mandate is able to call together consultative committees, and it would seem appropriate therefore that F.A.O. should consider providing such a committee on forestry within its framework. It could meet from time to time as might seem necessary in the opinion of F.A.O. and of the governments concerned acting in close consultation."

E. P. Stebbing

SCIENTIFIC APPROACH TO THE LACE INDUSTRY

In its treatment of scientific and technical research and development, the report of the Board of Trade Working Party on the Lace Industry*, of which Miss L. S. Sutherland was chairman and the late Prof. J. M. Gulland a member, follows similar lines to earlier reports from 'working parties' dealing with other textile industries. Like most of the latter, the machine-lace industry grew out of a craft, that of traditional hand-lace, and was not born of scientific research. In addition, it has always been, and still is, essentially a cotton industry, and in its essentials the industry remains the same as in the days of our grandfathers.

Speaking in very broad terms, in the past the lace industry in Britain has shown little interest in research. The total expenditure by individual firms on research appears to be small, and contribution to co-operative research by membership of research institutes such as the British Cotton Industry Research Association was by no means universal although fairly common. In spite of signs of a changing attitude in recent years, the 'working party' attributes many of the present urgent problems of the industry to its failure over a long period to investigate systematically and scientifically the textile, engineering and other aspects of the trade, not least important being those affecting health. One of the strongest recommendations in the report is, in fact, that the newly formed Research Council for the industry should press forward its investigations into a satisfactory substitute for graphite, the use of which as a lubricant for lace machines has given the machine-holding sections the character of a 'dirty trade'.

In characterizing the lace industry as a whole with indifference to research, with neglect of fundamental research and with a marked tendency for whatever research is prosecuted to be sporadic, and noting the absence of research staff and, except in the dressing section, even of scientific staff, the 'working party' frankly recognizes that no industry could achieve

*Board of Trade. Working Party Reports: The Lace Industry. (London: H.M. Stationery Office, 1947.) 3s. 6d. net.

products of such technical excellence as lace fabrics without a background of continual inquiry and trial. None the less, it is questionable whether inquiries into the use and handling of different yarns have in general been prosecuted with sufficient system to yield their full potential value. Investigations are frequently short-term projects to solve specific production problems, and are shelved when these have been overcome sufficiently for the immediate needs.

Valuable services have indeed been rendered to many firms by the Textile Testing Department, until very recently a part of University College, Nottingham, and by several research associations, but the 'working party' suggests that there are at least four factors restricting the development of research in the industry as a whole. As in the cotton industry, there has been lack of contact between the machine-holders and the machine-builders; the industry is almost entirely lacking in scientifically trained personnel in its higher ranks; the intense individualism of the industry has prevented a united approach to technical and other mutual improvements; and lastly, many machine-holders have taken a narrow view of their functions—to regard their function as limited to processing yarn supplied to them in a finished state with machinery planned and built by others, and to consider in consequence that little or no investigation is required of them other than innovations in design and yarn utilization, and handling.

These factors have to some extent been weakened by experience gained in co-operative research and production during the War, and the formation in January 1944 of a Technical and Research Committee of the Federation of Lace and Embroidery Employers' Associations led in June 1945 to the formation of a Lace Research Council, consisting of the members of the former Committee and the professors of botany (industrial mycology), chemistry, electrical engineering, physics and textiles of the University College of Nottingham. The Federation, however, was not disposed at that stage to establish a research association under the Department of Scientific and Industrial Research, but having guaranteed an income of £2,000 per annum for a period of three years, the Federation approached the latter Department to obtain Government assistance. As a result of this approach, the Research Council will have at its disposal a total income of £4,500 per annum during the three-year period and has already appointed as liaison officer in research matters a chemist of long experience of textile processes. The Council has, however, no laboratories and the duties of this solitary scientific officer are in the first place confined to formulating the problems and conditions facing the industry, maintaining contact with research associations and inaugurating investigations under contract at universities, technical colleges and elsewhere, and to the dissemination of information.

That, broadly, is the position which the 'working party'—whose conception and differentiation of research is in line with those detailed in the report of the Cotton Working Party—seeks to meet by what has now come to be the customary prescription of 'working parties', namely, a compulsory levy. It does not, indeed, suggest that a compulsory levy should be made solely for scientific and technical research: it is also intended to cover the financing of economic and market research, the promotion of overseas sales and the establishment of a design and fashion centre. The 'working party' does not go further than to suggest that the question whether the industry can afford not to inaugurate a fully fledged research association with its own staff, laboratory and workshop should be under constant review. It does not appear, however, to have contemplated any alternative to the usual research association for an industry in which much educational work is imperative before support can be won for research, and utilization of the results of research ensured.

COLOUR PHENOMENA IN THE PERCEPTION OF FINE DETAIL

IN a recent memoir, "The Visual Perception of Fine Detail", Prof. H. Hartridge has discussed the way in which "the image formed on the retina is clarified and improved before it reaches the higher centres of the brain", and considers in particular the reason why objects in white light are not seen surrounded by the coloured fringes which are certainly produced by the aberrations of the dioptric system of the eye (*Phil. Trans. Roy. Soc.*, B, **232**, 519; 1947). To throw light on this question, observations were made of the changes in apparent colour of coloured test objects, in some cases monochromatic stimuli, when their angular size was greatly reduced and when other factors—the brightness of the background, the proximity of other coloured objects, the pupil size, etc.—were modified.

While some of the results will be familiar to readers of Helmholtz ("Physiologische Optik", 2, 128 and 239–41, 3rd Edit.), many new observations are reported, and it is shown how they fit in with the apparent absence of fringes in ordinary vision. After skittling down a number of alternative hypotheses, Prof. Hartridge puts forward his own explanation of the changes in apparent colour. His 'neurological hypothesis' postulates four nervous mechanisms (antichromatic responses) which operate locally in all parts of the fovea and parafovea and the function of which is to control the connexion between photo-receptors and cranial centres. Thus the connexion between medium-wave receptors and the cranial centre for short waves is controlled by the 'yellow' mechanism, that between short-wave receptors and their cranial centre by the 'blue' mechanism. The mechanisms may also act together: the 'red' and 'green' mechanisms acting together change colourless vision to reduced (so-called diochromatic) vision, and 'yellow' and 'blue' mechanisms acting together then alter the latter to full colour vision. The neurological hypothesis is not a simple one, and without the answers to several questions, which Prof. Hartridge does not provide, it is difficult to form even a crude picture of the way the mechanisms work. It is not clear, for example, whether they have end-organs of their own or whether they must receive nervous stimuli from the photo-receptors which they are connecting or disconnecting with the cranial centres. More specific assumptions would seem necessary if any quantitative development of the hypothesis is to be possible.

To answer another main question, namely, the reason why at high intensities visual acuity depends so little on the colour of the light, Prof. Hartridge suggests that retinal receptors of each particular type (spectral response) tend to be collected in small clusters. Thus to see fine detail in blue light, the retinal image is brought on to a cluster of 'blue'

receptors; but if red light is used, there is a slight change of fixation to bring a cluster of 'red' receptors into action. Several experiments were made showing that slight changes in the direction of fixation for lights of different colours do occur. These changes in fixation, together with the changes observed in the apparent colour of very small test stimuli, are also regarded by Prof. Hartridge as strong evidence for the existence in the human retina of some seven types of receptor with narrow spectral sensitivity curves analogous to the modulator curves obtained in Granit's electrophysiological studies on animals (polychromatic theory of human vision).

One difficulty with this paper is that Prof. Hartridge has not only lost faith in the trichromatic theory, but he has also, it seems, abandoned the whole mode of approach through colour-matching measurements by which the purely empirical structure of the theory has been built up. One feels that the new ideas, if valid, must interlock with this empirical structure; but Prof. Hartridge does not show that they do.

W. S. STILES

FRUIT AND VEGETABLE CULTURE

THE annual report for 1945 of the Agricultural and Horticultural Research Station at Long Ashton, Bristol, gives results of the Station's work on the scientific horticulture of fruit and vegetable crops and on their products.

Classification of the visual symptoms of mineral deficiencies of crop plants is continued by E. J. Hewitt. He uses various refinements in technique, including a 'Permutit' demineralization method of purifying rain-water for studies of iron deficiency, and a method for transplanting adult plants without root disturbance. The present survey embraces deficiencies of twenty-nine crops grown in sand culture, and one incidental result is that a high nitrogen-level accentuates the symptom expressive of boron deficiency. Some of the effects of soil acidity on crops are not yet fully understood, and Hewitt also has a progress report on this matter. It would seem that some at least of the symptoms of acid damage are those of manganese toxicity, and other interesting tentative conclusions are mentioned. D. J. D. Nicholas has investigated the validity of rapid chemical tests for the diagnosis of mineral deficiencies in potato plants. He finds a welcome accord with the results of the full chemical analysis, and with the visual symptoms. Several useful correlations between deficiencies and toxicities are established. Spraying the foliage of tomato crops with 2 per cent magnesium sulphate solution is found to be a much better control of magnesium deficiency than soil applications of the same substance, according to D. J. D. Nicholas, J. O. Jones and T. Wallace. The director of the Station, Prof. T. Wallace, with E. Catlow, gives two extensive reports on the manuring of potatoes and garden beet respectively.

A useful classification of power-operated hydraulic spraying machinery for fruit crops has been prepared by H. G. H. Kearns. He gives broad specifications for the chief components of spray outfits, and estimates the biological requirements of spraying. Growers should find this paper a useful practical guide to the choice of this section of equipment. The advent of D.D.T. and benzene hexachloride makes it necessary to find the best methods of incorporating these sprays in a comprehensive programme. H. G. H. Kearns, R. W. Marsh and H. Martin have made experiments on this problem, which rather suggest that D.D.T. is an excellent insecticide against certain pests, but offers no widespread panacea of control. It was effective against leaf-curling aphids. Comparisons of three fungicides—tetramethylthiuram, ferric dimethyldithio-carbamate, and copper sebacate—were also included. The last-mentioned was approximately equal to lime sulphur as a fungicide. Other papers in this section deal with the flight period of the codling moth in relation to time of spraying (S. H. Bennett), the effect of early lifting and other factors on storage losses of onions (H. E. Croxall), attack of lettuce by two strains of the fungus *Bremia lactucæ*, and the relation of the disease to wild species of *Lactuca* (L. Ogilvie), and clover-rot investigations by Moira Munro and L. Ogilvie. The general features of eelworm attacks of vegetable crops are reviewed by H. W. Miles and Mary Miles, and A. J. Lloyd briefly outlines results of a biological method of estimating the intensity of clover stem eelworm infections in field soils. A short paper by May J. Haddock shows that the 'turnip flea beetle' is not a single species, but a complex of as many as eight species. They all seem to have a wide taste for cruciferous plants; but this numerical expansion of species does not seem to offer any change in methods of control.

The Station has also investigated problems relating to fruit and vegetable products. Workers in this field will find papers on the control of blackening of boiled potatoes, factors affecting quality in potatoes and tomatoes, the apple as a source of vitamin C, and the Station's major cider research.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LABORATORY ASSISTANT (Grade II) IN THE DEPARTMENT OF CHEMISTRY—The Secretary, Bedford College for Women, Regent's Park, London, N.W.1 (December 29).

VETERINARY INSPECTORS in the Ministry of Agriculture for Northern Ireland—The Secretary, Civil Service Commission, Stormont, Belfast (December 31).

ASSISTANT CHEMIST in the Chiswick Laboratory—The Staff Officer (ER/E. 457), London Passenger Transport Board, 55 Broadway, London, S.W.1 (December 31).

SENIOR LECTURER, and a READER, IN AGRICULTURE, at Makerere College, East Africa—The Secretary, Inter-University Council for Higher Education in the Colonies, 8 Park Street, London, W.1 (December 31).

QUALIFIED CHEMISTS in the Generating Stations at Chelsea and Neasden—The Staff Officer (ER/E. 454), London Passenger Transport Board, 55 Broadway, London, S.W.1 (December 31).

BACTERIOLOGIST to take charge of a public health laboratory service in Belfast—The Establishment Officer, Ministry of Health and Local Government, Stormont, Belfast (December 31).

RESEARCH FELLOW to work on the problem of origin and measurement of stresses in cast metal products—The Professor of Industrial Metallurgy, The University, Edgbaston, Birmingham 15 (December 31).

DEMONSTRATOR (part-time) IN THE PHARMACOLOGY DEPARTMENT—The Dean, Guy's Hospital Medical School, London, S.E.1 (December 31).

LECTURER IN ANATOMY at Makerere College, East Africa—The Secretary, Inter-University Council for Higher Education in the Colonies, 8 Park Street, London, W.1 (January 1).

LECTURERS (2, Grade IIc or IIb) IN CHEMICAL ENGINEERING—The Secretary, The University, Edmund Street, Birmingham (January 1).

LECTURER (Grade IIc) IN PHARMACOLOGY—The Secretary, The University, Edmund Street, Birmingham 3 (January 8).

SCIENTIFIC OFFICER IN THE BLOOD TRANSFUSION LABORATORIES, Manchester—The Regional Transfusion Officer, Royal Infirmary, Manchester 13 (January 10).

LECTURER (Grade IIc) IN ELECTRICAL ENGINEERING—The Secretary, The University, Edmund Street, Birmingham 3 (January 10).

SENIOR SCIENTIFIC OFFICER or SCIENTIFIC OFFICER (Ref. No. A.337/47), and a SENIOR EXPERIMENTAL OFFICER or EXPERIMENTAL OFFICER (Ref. No. F.773/47), at the Atomic Energy Research Establishment, Harwell, Didcot, Berks—The Ministry of Labour and National Service, Technical and Scientific Register, Room 669, York House, Kingsway, London, W.C.2, quoting appropriate Ref. No. (January 10).

DIRECTOR of a new Vegetable Research Station—The Chairman, Organising Committee, Vegetable Research Station, Ministry of Agriculture, Block 4, Bickenhall Mansions, Baker Street, London, W.1 (January 24).

DEPUTY CHIEF FUEL ENGINEER, London (male)—The Director of Establishments, Ministry of Fuel and Power, 7 Millbank, London, S.W.1, quoting 'Deputy Chief Fuel Engineer' (January 29).

PRINCIPAL MEDICAL OFFICER (Research), MEDICAL OFFICERS (Research, 3), a PRINCIPAL SCIENTIFIC OFFICER, SENIOR SCIENTIFIC OFFICERS (4), and EXPERIMENTAL OFFICERS (6), in the Chemical Defence Experimental Station, Porton, Wilts—The Secretary, Civil Service Commission, Scientific Branch, 27 Grosvenor Square, London, W.1, quoting No. 2075 (January 29).

CHANDOS PROFESSOR OF PHYSIOLOGY in the United College—The Secretary, The University, St. Andrews (February 28).

LECTURER IN STATISTICS—The Registrar, Trinity College, Dublin (March 1).

CHAIR OF GEOGRAPHY—The Registrar, University College, Exeter.

DEMONSTRATORS (2) IN THE DEPARTMENT OF BIOCHEMISTRY AND CHEMISTRY—The Dean of the Medical College, St. Bartholomew's Hospital, West Smithfield, London, E.C.1.

PLANT PATHOLOGIST for the East African Groundnut Scheme—The Personnel Manager (Technical), United Africa Co. (Managing Agency), Ltd., Unilever House, London, E.C.4.

HEAD LABORATORY TECHNICIAN, Grade A (organic or medical chemistry)—The Director, Wellcome Laboratory of Human Nutrition, Churchill Hospital, Oxford.

TECHNICIAN IN THE DEPARTMENT OF PHYSICS—The Secretary, University College London, Gower Street, London, W.C.1, quoting Physics/1.

PHYSICIST, PHYSICAL CHEMISTS (2), an ORGANIC CHEMIST, and a TEXTILE TECHNOLOGIST—The Acting Secretary, British Rayon Research Association, Bridgewater House, 58 Whitworth Street, Manchester 1.

ASSISTANT PUBLICATIONS OFFICER to deal with the editing, publication and distribution of research reports—The Secretary, Medical Research Council, 38 Old Queen Street, London, S.W.1.

METALLURGIST FOR THE LIAISON AND TECHNICAL SERVICE DEPARTMENT, and an INVESTIGATOR IN THE ANALYTICAL DEPARTMENT—The Secretary, British Non-Ferrous Metals Research Association, 81–91 Euston Street, London, N.W.1.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Imperial Bureau of Animal Breeding and Genetics, Edinburgh. Technical Communication No. 5: Gestation Periods; a Table and Bibliography. Compiled by Dr. J. H. Kenneth. Second edition. Pp. 30. (Aberystwyth: Imperial Agricultural Bureaux, 1947.) 3*s*. [94

Manchester Joint Research Council. Communication Series No. 2: Report of Conference on Research and the Smaller Firm, held on Wednesday, 16th October 1946, at the Albert Hall, Manchester. Pp. 102. (Manchester: Manchester Chamber of Commerce, 1947.) 2*s*. 6*d*. [94

The Road Back to Health: the Story of Medical Rehabilitation. (Published for the Ministry of Health.) Pp. 28. (London: H.M. Stationery Office, 1947.) 6*d*. net. [94

Forestry Commission. Bulletin No. 13: Studies on Tree Roots. Reprint. Pp. 72 + 17 plates. (London: H.M. Stationery Office, 1947.) 3*s*. 6*d*. net. [94

Ministry of Fuel and Power: Safety in Mines Research Board. Paper No. 105: The Prevention of Coal Dust Explosions, Part 1: The Effect of Manner of Distribution of Stone Dust. By S. Jones and F. V. Tideswell. Pp. 24. (London: H.M. Stationery Office, 1947.) 6*d*. net. [154

Federation of British Industries. Industrial Research in Technical Colleges. Report of a Special Sub-Committee of the F.B.I. Industrial Research Committee. Pp. 22. (London: Federation of British Industries, 1947.) [154

Watford Industrial Exhibition. Opened on 5th June 1947 by the Rt. Hon. Lord Brabazon of Tara and continuing until 18th June. Pp. 60. (Watford: Town Hall, 1947.) [154

The Life and Work of George Gerald Henderson. By Prof. Sir Ian Heilbron. (First Henderson Memorial Lecture.) Pp. 12. (London: Royal Institute of Chemistry, 1947.) [154

The History and Prevention of Silicosis, with Special Reference to the Witwatersrand. By Dr. A. J. Orenstein. (First Sir Julius Wernher Memorial Lecture.) Pp. 19. (London: Institution of Mining and Metallurgy, 1947.) [154

Reports of the Council and Auditors of the Zoological Society of London for the Year 1946. Pp. 46. (London: Zoological Society of London, 1947.) [174

Department of Scientific and Industrial Research: Standing Consultative Conference on Fuel Research. Fuel Abstracts. New Series, Vol. 1, No. 1, January: Abstracts Nos. 1 to 522 and Subject Index. Pp. ii + 128 + xvi. (London: H.M. Stationery Office, 1947.) 50*s*. per annum. [174

British Electrical and Allied Manufacturers' Association. Report of the Council for the Year 1946–47. Pp. 32. (London: British Electrical and Allied Manufacturers' Association, 1947.) [174

John Innes Horticultural Institution, Merton and Hertford. Thirty-seventh Annual Report, 1946. Pp. 32. (London: John Innes Horticultural Institution, 1947.) [174

Further Education: a Monthly Review of Planning and Progress. Vol. 1, No. 1, April. Pp. 24. (London: Turnstile Press, Ltd., 1947.) 1*s*. 6*d*. net. [224

Other Countries

Carnegie Institution of Washington. Publication 551: Contributions to Paleontology—Fossil Vertebrates from Western North America and Mexico. By E. L. Furlong, E. Raymond Hull, Lore Rose David, Robert E. Wallace and Hildegarde Howard. Pp. iii + 195 + 31 plates. (Washington, D.C.: Carnegie Institution, 1946.) 2.50 dollars. [313

Smithsonian Institution: United States National Museum. Bulletin 191: Life Histories of North American Jays, Crows and Titmice. Order Passeriformes. By Arthur Cleveland Bent. Pp. xi + 495 + 6 plates. (Washington, D.C.: Government Printing Office, 1946.) [313

A Five Year Plan for the Geological Survey of India: Memorandum on the Expansion and Reorganisation of the Geological Survey of India. Pp. ii + 25. (Calcutta: Government of India Press, 1946.) [313

Ministry of Public Works, Egypt: Physical Department. Paper No. 51: The Nile Basin. By Dr. H. E. Hurst, R. P. Black and Y. M. Simaika. Vol. 7: The Future Conservation of the Nile. Pp. xv + 13 + 27 plates. (Cairo: S.O.P. Press, 1946.) P.T. 125; 25*s*. [313

Report of His Majesty's Astronomer at the Cape of Good Hope to the Secretary of the Admiralty for the Year 1942. Pp. 6. Report of His Majesty's Astronomer at the Cape of Good Hope to the Secretary of the Admiralty for the Year 1943. Pp. 7. Report of His Majesty's Astronomer at the Cape of Good Hope to the Secretary of the Admiralty for the Year 1944. Pp. 8. (Cape of Good Hope: Royal Observatory, 1943–1945.) [94

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State of California Department of Natural Resources: Division of Fish and Game, Bureau of Marine Fisheries. Fish Bulletin No. 6: Analysis of Populations of the Pacific Sardine on the Basis of Vertebral Counts. By Frances N. Clark. Pp. 26. (Terminal Island, Cal.: Department of Natural Resources, 1947.) [94

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Canada: Department of Mines and Resources: Mines and Geology Branch, Bureau of Mines. No. 817: Peat Moss Deposits in Canada. By Harold A. Leverin. Pp. v + 102 (9 plates). (Ottawa: King's Printer, 1946.) 25 cents. [94

Government of Cyprus. The Proceedings of a Conference on Land Use in a Mediterranean Environment, held in Nicosia, Cyprus, 16th–17th April, 1946. Pp. 55. 7*s*. Report of the Land Utilization Committee, 1946. Pp. 32. 5*s*. (Nicosia: Government Printing Office, 1946–1947.) [94

Commonwealth of Australia: Council for Scientific and Industrial Research. Bulletin No. 167: The Detonation of Nitroglycerine by Impact. By Dr. F. P. Rowden, Dr. F. Eirich, A. E. Ferguson and A. Yoffe. Pp. 44 + 8 plates. Bulletin No. 173: The Detonation of High Explosives by Impact; The Sensitivity, and the Propagation of the Explosion in Liquids. By Dr. F. P. Rowden, Dr. R. Eirich, M. F. I. Mulcahy, R. G. Vines and A. Yoffe. Pp. 75 + 34 plates. Bulletin No. 195: An Account of Experiments undertaken to Determine the Natural Population Density of the Sheep Blowfly, *Lucilia cuprina* Wied. By Darcy Gilmour, D. F. Waterhouse and G. A. McIntyre. Pp. 39 + 3 plates. Bulletin No. 196: Transmission of Potato Virus Diseases, 5, Aphid Populations, Resistance and Tolerance of Potato Varieties to Leaf Roll. By Dr. J. G. Bald, D. O. Norris and G. A. H. Nelson. Pp. 32. Bulletin No. 199: The Use of Mineral Dusts for the Control of Wheat Pests. By Frank Wilson. Pp. 31 + 1 plate. (Melbourne: Government Printer, 1943–1946.) [154

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Forest Research in India and Burma, 1944–45. Part 1: The Forest Research Institute. Pp. iii + 149. (Dehra Dun: Forest Research Institute, 1946.) 3.8 rupees; 5*s*. 6*d*. [174

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Papers in Physical Oceanography and Meteorology published by Massachusetts Institute of Technology and Woods Hole Oceanographic Institution. Vol. 10, No. 1: Measurements of Temperature and Humidity in the Lowest 1000 Feet of the Atmosphere over Massachusetts Bay. By Richard A. Craig. (Contribution No. 362 from the Woods Hole Oceanographic Institution.) Pp. 43. (Woods Hole, Mass.: Woods Hole Oceanographic Institution, 1946.) 75 cents. [224

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